

*Volume 1*

**Performance Based Regulations:  
The Viability of the Modelling Approach as a Methodology  
for Building Energy Compliance Demonstration**

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# Student Declaration

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The author of this thesis, Miss Rokia Raslan, confirms that the work presented in this thesis is her own. Where information has been derived from other sources, the author confirms that this has been indicated in the thesis.

Signature:

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# Abstract

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*With the increasing international shift from prescriptive to performance-based regulations, a legislative call for the integration of predictive assessment tools in the design process has emerged. In relation to this, the requirements of Article 3 of the Directive on Energy Performance of Buildings (EPBD) were transposed into UK legislation with the introduction of the Building and Approved Inspectors (Amendment) Regulations 2006 (England and Wales) in April 2006. These introduced the 'National Calculation Methodology' (NCM), a unified compliance demonstration route for energy performance criteria specified in Approved Document Part L (Conservation of Fuel and Power), supported through the use of modelling-based building energy performance prediction (BEPP) tools accredited for the purposes of implementing associated calculations.*

*This thesis presents an assessment of adopting the methodology, utilising a mixed-method research design to investigate key parameters identified as measures by which to quantify the success of this approach. Firstly, the adaptive capability of the UK construction industry is assessed through the analysis of primary data collected from a longitudinal survey. Secondly the applicability of the methodology is analysed through in-depth interviews examining the role of key actors and the varying dynamics of implementation and enforcement. Finally, a comparative evaluation is carried out to assess the adequacy of accredited BEPP tools.*

*The main findings outline the shortcomings of the adaptation strategy adopted by industry and the inconsistent implementation and enforcement strategies employed. The results of the comparative tool study in particular highlight three important issues; a large degree of predictive variability between key compliance benchmarks, the lack of consistency in granting approval (a pass/fail result) between tools and limitations in the scope of their applicability. The research concludes that although a number of positive aspects can be associated with the introduction of a modelling-based approach for compliance demonstration, due to the aforementioned issues, considerable efforts are still required to extend its usefulness as a credible legislative support tool for performance-based regulations.*

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# Glossary

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**Anthropogenic climate interference** is the change in the Earth's climate (forcing) that can be attributed to human related activities.

**Building energy performance** is the amount of energy actually consumed or estimated to meet the different needs associated with a standardised use.

**Building energy performance prediction** is the science of estimating the energy interactions within a building.

**Climate change** is a persistent long-term change in the mean and/or the variability of the properties of Earth's climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

**Forcings** are external factors that affect the Earth's climate system.

**Modelling** can be described as the process of developing a model which faithfully represents a complex system, of which buildings are one type.

**Performance assessment** involves the evaluation of predicted performance based on the knowledge of what is desired and what is possible.

**Performance prediction** involves the development of models that attempt to replicate or account for the interactions within a building and estimate its future behaviour.

**Radiative forcing** measures the change in the balance between radiation coming into the atmosphere and radiation going out, where a positive radiative forcing tends on average to warm, and negative forcing tends on average to cool the surface of the Earth.

**Simulation** is a (virtual) experiment that involves the reproduction of the physical behaviour of a system to create a virtual abstracted equivalent behavioural model of the building and provide transient simulations of energy transfers within it.

# Abbreviations and Symbols

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## Abbreviations and Acronyms

ACAI	Association of Consultant Approved Inspectors
ACT	Actual Building
AI	Approved inspector
ADLs	Approved Documents for Part L
ADL1A	Approved Document L1A - Conservation of fuel and power in new dwellings
ADL1B	Approved Document L1B - Conservation of fuel and power in existing dwellings
ADL2A	Approved Document Part L2A- Conservation of fuel and power in new buildings other than dwellings
ADL2B	Approved Document L2B Conservation of fuel and power in existing buildings other than dwellings
BCB	Building control body (local authority building control and approved inspectors)
BCO	Local authority building control officer
BEPP	Building Energy Performance Prediction
BER	Building Emissions Rate
BRUKL	Building Regulations UK Part L compliance output document
CIBSE	The Chartered Institution of Building Services Engineers
DEC	Display Energy Certificate
DHW	District Hot Water
DSM	Dynamic Simulation Model
FI-SBEM	Front end- Interface Simple Building Energy Model
EPBD	European Directive on Energy Performance of Buildings
EPC	Energy Performance Certificate
HVAC	Heating Ventilation and Air Conditioning (Systems)
IMP	Improvement Factor in the compliance calculation equation
iSBEM	Interface (to) Simple Building Energy Model
LABC	The trading name of District Surveyors Association Limited, the member organisation representing Local Authority Building Control departments in England and Wales
LZC	Low Zero Carbon Benchmark in the compliance calculation equation
NCM	National Calculation Methodology
NOT	Notional Building
RIBA	Royal Institute of British Architects
SAP	Standard assessment procedure for the energy rating of dwellings < 450m <sup>2</sup> floor area
SBEM	Simple Building Energy Model
TER	Target Emissions Rate

## Greek Symbols

$\kappa_m$ value	Internal Heat Capacity kJ/m <sup>2</sup> K
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## Statistical Symbols

$df$	Degrees of freedom
$q$	Significance of variables
$\chi^2$	chi-square distribution
$std$	standard deviation



## **Publications and Key Presentations Arising from this Thesis**

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### **Articles in Refereed Journals**

Raslan R. & Davies M., 2009. Results Variability in Accredited Building Energy Performance Compliance Demonstration Software in the UK: An Inter-Model Comparative Study. *IBPSA Journal of Building Performance Simulation (JBPS)*

Raslan R. & Davies M., 2010. An Analysis of Industry Capability for the Implementation of a Software Based Compliance Approach for the UK Building Regulations 2006. *Building Services Engineering Research & Technology (BSERT)*

### **Articles in Refereed Proceedings**

Raslan R., Davies M. & Doyle N., 2009. An Analysis of Results Variability in Energy Performance Compliance Verification Tools. *11th International IBPSA Conference*, University of Strathclyde, Glasgow, Scotland – 27-30 July 2009

Raslan R., Davies M. & Oreszczyn T., 2007. The Establishment of a Simulation Capability to Support the England & Wales Building Regulations 2006. *10th International IBPSA Conference*, Tsinghua University, Beijing, China – 3-6 September 2007

Raslan R. & Davies M., 2007. An Assessment of the Simple Building Energy Model. *CISBAT 2007 Conference*, Lausanne, Switzerland, 4-5 September 2007

Raslan R. & Davies M., 2006. The Implementation of a Simulation-Based Compliance Methodology for the UK Building Regulations 2006: An Industry Survey. *European Modelling Symposium 2006*. UK Simulation Society & the Graduate School, University College London. 11-13 September 2006

### **Key Presentations**

Raslan R., 2010. Predictive Variability in Energy Performance Compliance Verification Tools: Issues and Implications. Presentation to the Chief Scientist Forum. Department of Communities and Local Government. London, 30 April 2010

Raslan R., 2010. Is SBEM the Way Forward? Invited Speaker - CIBSE National Conference 2010 Resilience and Building Services: How to secure the future, London, 27-28 April 2010

Raslan R., 2010. Results Variability in Non-Domestic Energy Performance Compliance Verification Tools. Invited Speaker - Zero Carbon Hub CCA Task Group Meeting, London, 25 January 2010

# Chapter 1: Introduction

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*In April 2006, the new Building and Approved Inspectors (Amendment) Regulations 2006 came into force, introducing the National Calculation Methodology (NCM), as the unified compliance demonstration methodology for Approved Document Part L, the relevant technical guidance document pertaining to the energy performance and energy efficiency targets of buildings. The following provides an introduction to a study undertaken in an aim to assess the viability of the NCM as a compliance methodology for energy performance and its effect on the credibility of the performance-based approach to regulation as a whole.*

## **1.1-Rationale for the Study: Research Background**

The Intergovernmental Panel on Climate Change (IPCC) has in recent years led the effort in the study of long-term temperature and weather patterns and the production of what are considered to be the most authoritative global projections of future scenarios of climate change (IPCC 2007a), the effects of which are highlighted by these and other projections. It is now accepted by a consensus of scientific opinion that human activities are a significant contributing factor to these changes, presenting a serious threat to both human society and the environment (e.g. Forster et al. 2007; Stern 2007; Hassol & ACAI 2004).

The building sector is a major consumer of energy, accounting for approximately 38% of the total global primary energy use and 25% of energy-related CO<sub>2</sub> emissions (de la Rue du Can & Price 2008; Price et al. 2006; Levine et al. 2007; Huovila 2007). Consequently, the introduction of meaningful and effective regulation to set the standard for energy efficiency in buildings (SERA 2005) is a key element in reducing the annual rate of increase of emissions in the sector, and in the wider scope, a critical factor in ensuring a more sustainable future (Sorrell 2003).

A goal-oriented performance-based approach to building regulation emerged in the 1970s as a result of an emerging interest in developing and implementing a legislative system that could address the difficult task of reconciling societal goals with issues concerning environmental consciousnesses, energy security and energy efficiency (Barlow & Bhatti 1997; Janssen 2004; Meacham et al. 2003; Sorrell 2003; Thomas 2003). This approach has since become the most widely adopted means for enhancing building energy efficiency through the determination of energy performance goals related to the limitation of such factors as energy consumption levels or resulting emissions (Lee & Yik 2004).

For a performance-based regulatory system, a method by which to assess and verify the performance of a proposed solution is a fundamental aspect in ensuring the applicability of the approach (Hensen & Nakahara 2001). Traditionally, these methods have included such approaches as the use of design guidelines or rules of thumb, traditional physical calculations and correlation based methods. In recent years, developments in this field have increasingly involved the use of computational assessment in the form of modelling-based building energy performance prediction (BEPP) tools. If utilised correctly, these tools can potentially provide the most accurate and cost-effective option for the prediction of the behaviour of an unrealised building (de Wilde 2004), consequently a global trend calling for their increased integration has therefore emerged.

In following this trend, the Energy Performance of Buildings Directive-EPBD (Official Journal of the European Communities 2002) was introduced in 2002. Article 3 of the EPBD specifically requires that member states apply a 'National Calculation Methodology' (NCM) - a unified approach for the demonstration of compliance with building energy performance standards. In transposing this requirement into UK legislation, among the various changes included in the Building and Approved Inspectors (Amendment) Regulations 2006 (England and Wales), a single methodology utilising BEPP tools was specified as the compliance verification route for the energy performance criteria defined in the relevant technical guidance document, Approved Document Part L (DCLG 2006b).

While the potential benefits associated with this approach have been recognised, its implementation requires a substantial shift in existing industry practices. In addition, a review of relevant literature discussing the use of computational assessment in the building design process has highlighted two important issues that may present a challenge to the effective implementation of the NCM:

- Barriers to the uptake of tools: These include such issues as the unavailability of appropriate tools and/or models, the extent of associated costs and a lack of the required degree of expertise (e.g. Hensen & Augenbroe 2004; de Wilde 2004; McElroy et al. 2001).
- The phenomena of predictive variability found in building energy prediction tools: This has been established in previous studies in the field (e.g. Judkoff & Neymark 2006; Neymark & Judkoff 2002; Karlsson et al. 2007), but has particular significance in this case as it potentially calls into question the credibility of the NCM as an approach for legislative compliance.

## **1.2-Research Questions, Aims and Objectives**

In considering the potential challenges surrounding the use of building energy performance prediction, this research aims to present an objective assessment of the viability and applicability of the approach for demonstrating compliance within the framework of performance-based regulations. This is undertaken in the specific context of the experience of introducing the

National Calculation Methodology (NCM) for the new non-domestic sector as set out in Approved Document Part L2A of the (Amendment) Building Regulations 2006 (England and Wales).

As a form of exploratory research that intends to gain familiarity with a novel subject area and achieve new insights into it, this thesis aims to answer the following three research questions:

- How effective are the measures adopted by the UK construction industry and associated parties to accommodate the required changes, and consequently, realise the associated goals of the approach?
- What are the varying dynamics of the application of this approach in practice? And what is the possible influence on the design process?
- How will the uncertainties surrounding the use of building energy performance prediction (BEPP) tools impact the credibility of the NCM as a methodology for compliance demonstration?

By identifying the associated contextual issues in applying the approach, then discussing their implications in the defined context, the detailed objectives of the study are to:

- Discuss the potential issues concerning the effectiveness of the NCM as an approach for demonstrating compliance for energy performance.
- Provide an evaluation of the status and adaptability of the UK industry to support the NCM and in addressing subsequent changes.
- Examine the role of key actors, the varying dynamics of application and the potential issues associated with its use.
- Investigate the role of enforcement in checking results and confirming compliance.
- Examine the suitability of accredited building energy performance prediction (BEPP) tools for the purposes of compliance demonstration.
- Investigate the possibility, extent and impact of predictive variability in accredited tools.

Through documenting the process of the introduction of this legislative approach and identifying the key issues experienced, this study aims to make an original contribution to knowledge through the provision of recommendations and measures to both address emerging issues and better inform future revisions of Part L, an integral component of the overall building energy efficiency agenda.

### 1.3-The Delimitations and Limitations of the Study

The delimitations of a study are those characteristics that define the boundaries of the investigation. These are determined through the conscious exclusionary and inclusionary decisions that are made throughout the development of the research proposal (Cline & Clarke 2000), and are further refined through the undertaking of a literature review.

In conducting this research, for issues of practicality in scoping the study, the following boundaries of inquiry were initially defined:

- The UK legislative structure is based on devolved administrations subdivided into three jurisdictions (England and Wales, Scotland and Northern Ireland); each governed by a separate body and regulation documents (BRC 2003). The study only sought to assess the specific implementation of the requirements of the NCM with regard to the case of England and Wales. However, due to the commonalities between the systems and the BEPP tools used across these jurisdictions (Liu 2007), the issues that are highlighted in the findings of this study can be extrapolated and assumed to be generally applicable to all the UK administrations.
- Separate approaches for implementing the NCM are defined for the two sectors that make up the built environment (domestic and non-domestic). The approach defined for the domestic sector was based on the well-established and more simplified Standard Assessment Procedure (SAP). The focus of this study was therefore to specifically assess the case of the new non-domestic sector and the requirements of the relevant Approved Document Part L2A (new buildings other than dwellings). Here, a relatively novel and more complex approach supported by modelling-based BEPP tools was used.

The limitations of a study are those aspects of the research design or methodology that set parameters on the application of the investigation. These are considered to be beyond the control of the researcher (Gay & Airasian 2002) and present constraints on the interpretation of results and the extent to which findings can be generalised (Cline & Clarke 2000).

Since this study was conducted during the implementation of what were at the time ongoing developments in legislation, it therefore-upon completion-provides a retrospective assessment. In considering the cycle of legislative reviews, it is also important to recognise that although some research results may be in essence time-limited, the main findings and recommendations they give rise to can however *generically* be considered of continued value and importance in informing the development of future revisions.

### 1.4-Methodological Overview: The Mixed-Methodology Approach

In concurrence with the exploratory nature of the research, the determination of the research design was undertaken as an iterative process. In view of the main goal of the study, this process considered aspects such as the domain, objectives and the nature of the research subject itself in the selection of the appropriate methodology.

Accordingly, a mixed-method design was considered to be the most appropriate for this purpose due to its effectiveness in combining both quantitative and qualitative approaches and its flexibility in integrating the various research instruments for data collection associated with each. This method has the potential to increase the validity and reliability of the resulting data and strengthens causal inferences by providing the opportunity to observe data convergence or divergence in testing emerging hypotheses (Tashakkori & Teddlie 1998; Abowitz & Toole 2010).

The general framework of the research design and application of the mixed-method approach are outlined in Chapter 5, where a brief description of each of the research instruments employed (survey, in-depth interview and comparative analysis of tools) is given. The process of applying each of these is discussed in more detail in the relevant sections of the thesis.

### 1.5-Research Structure and Chapter Layout

The research is structured into three parts, each of which adopts a main theme that relates to the sequential stages of the research methodology ('review-analysis-synthesis') as outlined in Figure 1.1. The organisation of the chapters within this framework can be described as follows:

#### Part 1: Review

- **Chapter 1: Introduction**

An introduction to the study discussing the relevant background of the research, the definition of the main research questions and consequent aims and objectives. The research methodology and the main structure of the thesis are outlined.

- **Chapter 2: The Context of the Study - Climate Change and the Built Environment**

A review of relevant literature that discusses the background issues that underlie the main concepts forming the basis of the research. These include the issue of climate change, the environmental impact of the built environment and associated approaches to mitigation. Regulatory policy instruments are discussed with a specific focus on the critical role of the performance-based approach in setting the standard for energy efficiency.

- **Chapter 3: Predicting Building Performance-Methods and Tools**

An overview of the basic concepts and principles of building energy performance prediction. The properties of various building energy performance prediction (BEPP) tools are outlined and their integration into the design process in the specific context of the assessment and verification of compliance for performance-based regulations is discussed. Potential issues and barriers affecting the uptake of integrated performance prediction are also highlighted.

- **Chapter 4: The Regulation of Building Energy Performance in the UK**

A discussion of energy regulation affecting the UK built environment and the application of the National Calculation Methodology in the particular context of the non-domestic sector in England and Wales. The methodological framework, basic concepts and principles of the process are defined and the properties and accreditation process of BEPP tools used for compliance verification are discussed. The various drivers and potential issues associated with implementation are also highlighted.

## **Part 2: Analysis**

- **Chapter 5: Study Methodology**

A definition of the main areas of interrogation and exploration of the various approaches for conducting research. A framework for the conceptualisation and operationalisation of a research methodology based on a mixed-method design is consequently outlined and the various research instruments used in the study are discussed.

- **Chapter 6: Industry Survey-Trends and Adaptability**

The chapter describes an empirical longitudinal survey-based industry study. The survey was implemented in a two-stage format; each administered at a key stage in the implementation of the NCM. This allowed the collection of time-relevant information gauging industry response to the introduction of the NCM and the effectiveness of the approach adopted to accommodate the transition.

- **Chapter 7: Industry In-Depth Interviews- Analysis of Application Dynamics**

A detailed insight into the application of the NCM in practice through the analysis of descriptive qualitative interview data. Key informants involved in both the application and enforcement of the NCM for Approved Document Part L2A were selected as study participants.

- **Chapter 8: Comparative Analysis of Accredited Building Energy Performance Prediction Tools**

An inter-model comparative study of accredited BEPP tools that examines the extent of variability in the results of key parameters included in the generated 'BRUKL' compliance document.

**Part 3: Synthesis**

- **Chapter 9: Analysis of Data and Discussion**

An analysis of the findings reported in the core chapters constituting the 'analysis' stage of the research, applied through the implementation of a triangulation methodology. The findings are related back to the contextual issues highlighted in the relevant literature discussed the 'review' stage of the study. The chapter also discusses the future implications arising from this research and consequently recommendations that address major issues are presented.

- **Chapter 10: Conclusions of the Research**

This chapter highlights the main conclusions of the research and discusses its original contribution to knowledge. The practical application of the findings of the research through dissemination activities is highlighted. Gaps in current knowledge are identified and a body of future work is proposed.



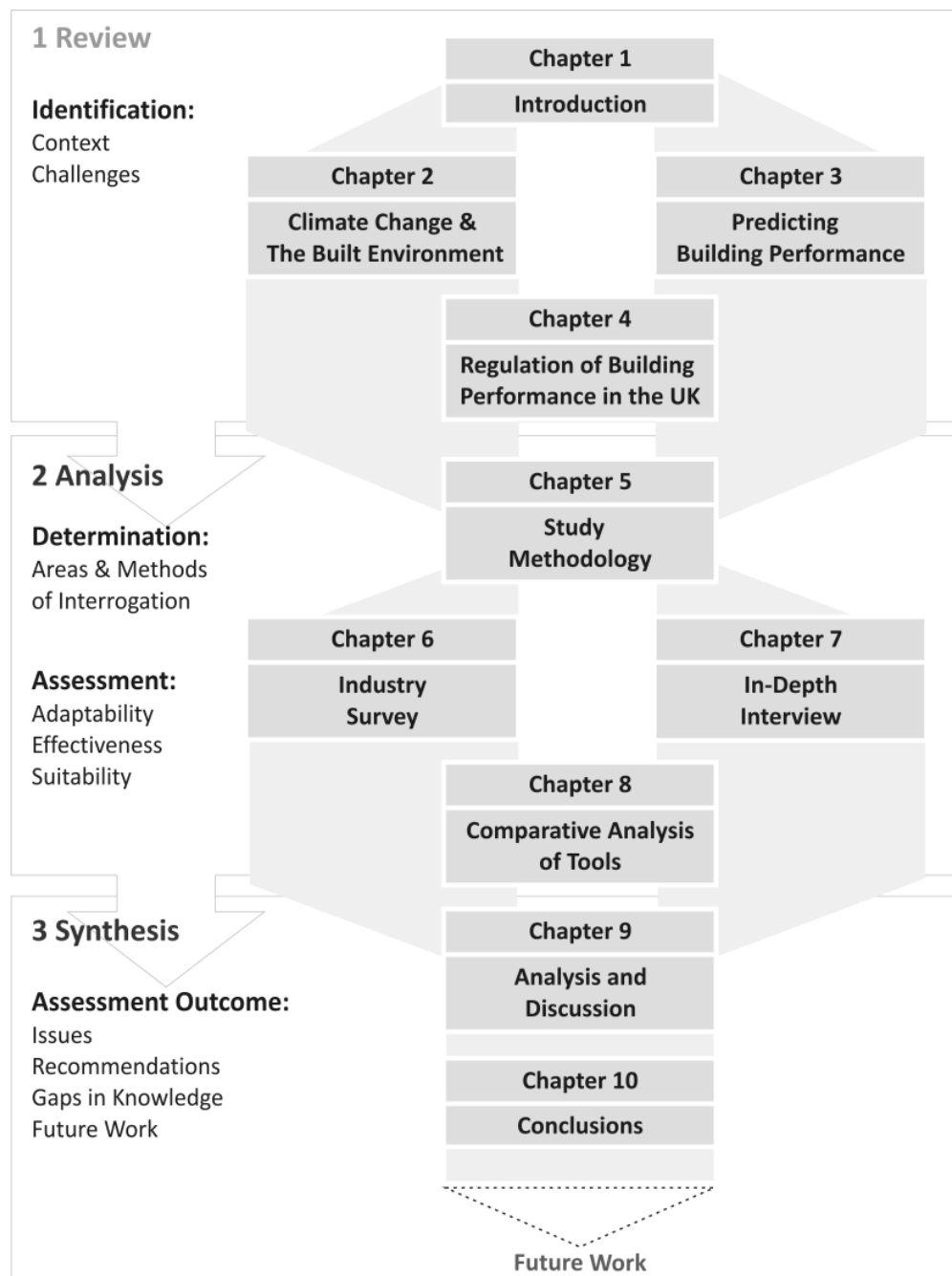


Figure 1.1: Research information flow: Scoping of the study

## Chapter 2: The Context of the Study - Climate Change and the Built Environment

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*This chapter details the relevant background issues that underlie the main concepts forming the basis of this research. The impacts of climate change are first examined and the scientific evidence supporting the argument that human activities are significantly changing the global climate is presented (DEFRA 2006a). The particular impact of the built environment as a major consumer of energy is outlined. Associated approaches to mitigation - in particular regulatory policy instruments - are discussed, highlighting the critical role of the performance-based approach in setting the standard for energy efficiency in buildings and ensuring a sustainable future (SERA 2005; Sorrell 2003).*

### 2.1-The Climate Change Context

The Intergovernmental Panel on Climate Change (IPCC) has in recent years led the effort in the study of long-term temperature and weather patterns and the production of what are considered to be the most authoritative global projections of future scenarios (IPCC 2007a). Through these and other efforts, the dynamic nature of the Earth's climate system has been established and the influential role of both its own internal dynamics in addition to changes in external factors or 'forcings' has been discussed (Le Treut et al. 2007).

Observational and analytical scientific evidence that has been accumulating over the past decades has made a strong case for anthropogenic climate interference: the forcing that can be attributed to human related activities. These activities are thought to alter the composition of the global atmosphere (Sanders & Phillipson 2003; IPCC 2007b; Carbon Trust 2002) resulting in the long-term variations in temperature and weather patterns referred to as 'climate change'<sup>1</sup> (UNFCCC 2002; Grubb 2005; IPCC 2007a).

The potential influence of external factors as climate change mechanisms is quantified through the effect of each component on the radiative energy budget of the Earth's climate system. This is

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<sup>1</sup> A change in the state of the climate is identified as a persistent long-term change in the mean and/or the variability of its properties. The term 'climate change' is used here in accordance with the UNFCCC usage which considers change that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. In IPCC usage, the term refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC 2007a).

compared through the Radiative Forcing Index (RF)<sup>2</sup> (Le Treut et al. 2007; US National Research Council 2005). The combined effect of human-related activities - the anthropogenic RF levels - measured in 2005 was  $+1.6 [-1.0, +0.8]^2 \text{ Wm}^{-2}$ . This indicates the extreme likelihood<sup>3</sup> of the occurrence of the suggested anthropogenic interference scenario and the resulting global warming phenomenon (Forster et al. 2007). The negative potential effects (as well as those already observed) of this increase in average global air and ocean temperatures (Figure 2.1) have been widely discussed in relevant literature (e.g. Stern 2007; Smith et al. 2009) and extensively reported in successive IPCC reports (1990, 1995, 2001 and 2007). The supporting evidence and objections raised by sceptics regarding the human contribution to this phenomenon is also well documented (Carbon Trust 2002).

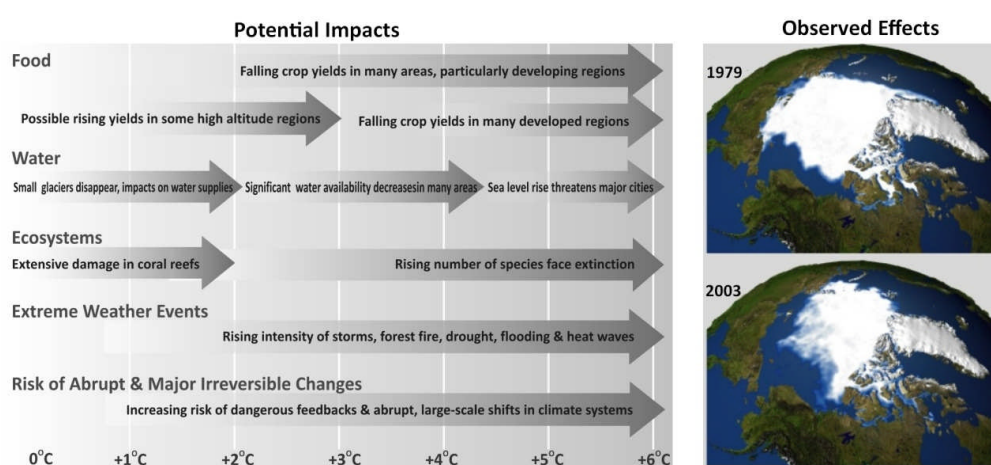


Figure 2.1: Potential impacts and observed effects of climate change: Projected effects of a rise in global temperatures (left) and the reduction of the Northern ice cap as a result of global warming 1979-2003 (right)  
Sources: Stern 2007; Hassol & ACAI 2004

### 2.1.1-Green House Gases and the Carbon Indicator

The five major long-lived and well mixed green house gases (GHGs) include methane ( $\text{CH}_4$ ), Nitrous Oxide ( $\text{N}_2\text{O}$ ) and Carbon Dioxide ( $\text{CO}_2$ ), which are primarily produced as by-products of the combustion of fossil fuels to meet energy consumption demands, and the halogenated compounds (mainly Chlorofluorocarbons CFC11 and CFC12) (Figure 2.2).

Various studies that have examined the perturbation to radiative climate forcing have identified these gases as the primary contributor to the combined anthropogenic RF, where they are thought to account for about 96% of the associated direct radiative forcing increases since 1750 (Rogner et

<sup>2</sup> The concept of Radiative Forcing measures the change in the balance between radiation coming into the atmosphere and radiation going out. For most analyses measurements are compared against pre-industrial data from 1750 (an arbitrarily designated baseline year). The results are expressed in  $\text{Wm}^{-2}$ , where a positive radiative forcing tends on average to warm, and negative forcing tends on average to cool the surface of the Earth (UNEP/GRID-Arendal 2009).

<sup>3</sup> Statistically defined as a 95% confidence level or higher (IPCC 2007a)

al. 2007; Le Treut et al. 2007; NOAA/ESRL 2009). While a significant overall increase in the atmospheric concentration of the five major GHGs has been recorded, the rate of increase of CO<sub>2</sub> and NO<sub>2</sub> in particular continues to grow (NOAA/ESRL 2009). Comparative measurements from 1998 and 2008 show that CO<sub>2</sub> accounted for nearly 80% (~0.45 Wm<sup>-2</sup>) of the increase in GHG-related radiative forcing measured during that period (NOAA/ESRL 2009). Future emissions estimates also suggest that CO<sub>2</sub> will account for approximately 63% of the net radiative forcing over the next 100 years (DEFRA 2006a).

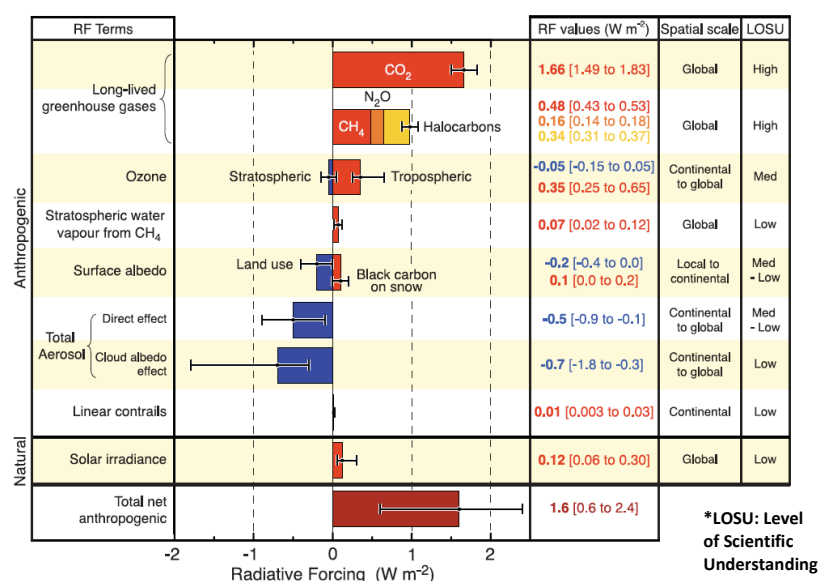


Figure 2.2: Radiative forcing components: Various factors influencing the climate  
Source: IPCC 2007

As the most significant anthropogenic GHG, CO<sub>2</sub> has therefore been widely adopted as the primary indicator of the magnitude of climate change with the effect of other GHGs accounted for in terms of CO<sub>2</sub>-equivalent emissions (CO<sub>2</sub>e)<sup>4</sup> (Levin & Bradley 2009). The standard measurement for both of these is usually expressed as MtCO<sub>2</sub> (million tonnes of CO<sub>2</sub>) or GtCO<sub>2</sub> (giga tonnes of CO<sub>2</sub>). Although the recent Hartwell Paper has criticised the over-emphasis of the importance of CO<sub>2</sub> and the side-lining of other non-CO<sub>2</sub> forcing agents from the previous climate policy regime (Prins et al. 2010), it is expected that CO<sub>2</sub> emissions will continue to be the most widely recognised and adopted indicator of the magnitude of climate change.

The annual mean growth rate in the atmospheric concentrations<sup>5</sup> of CO<sub>2</sub> has fluctuated extensively, ranging between a minimum value of 0.29 ppm/yr (1964) and peaking at 2.93 ppm/yr (1998) with a current level that stands at 1.76 ppm/yr (2009) (ESRL/NOAA et al. 2010). Recent

<sup>4</sup> CO<sub>2</sub> emissions will be mainly used as the standard indicator of emissions throughout this thesis. Where figures are originally cited in relevant literature as CO<sub>2</sub>e emissions this is converted according to the convention 1 metric tCO<sub>2</sub>e = approximately 3.66 metric tCO<sub>2</sub> (EPA 2010).

<sup>5</sup> The atmospheric concentrations CO<sub>2</sub> have been continually tracked through the high-accuracy Mauna Loa Observatory readings initiated in 1958 by Keeling (Keeling 1961; Keeling 1998).

measurements taken in January 2010 show that the current CO<sub>2</sub> concentration stands at just under 390 ppm, an increase of approximately 40% compared to the presumed pre-industrial level of 280 ppm (ESRL/NOAA et al. 2010).

In 1996, the European Council asserted that to avoid the most extreme consequences of global warming referred to as 'dangerous anthropogenic interference' (DAI), global average temperatures should not exceed 2°C above pre-industrial levels (European Council 2005). To achieve this goal, an overall target peak level of 400 to 450 ppm CO<sub>2</sub> and a stabilisation level of around 380ppm CO<sub>2</sub> would be required (Hassol 2008). More recent evidence has led to the revision of this target to 1°C, which would require an even lower stabilisation level of 350 ppm CO<sub>2</sub> (Hansen et al. 2008).

Future projection models outlining various emissions scenarios (IPCC 2001) suggest that the rate of increase is in large part dependent on socio-economic factors. It is therefore thought that these emissions can be significantly reduced through the implementation of more sustainable developmental policy options that strive to reduce energy demand by adopting energy efficiency measures in various socio-economic sectors (Figure 2.3).

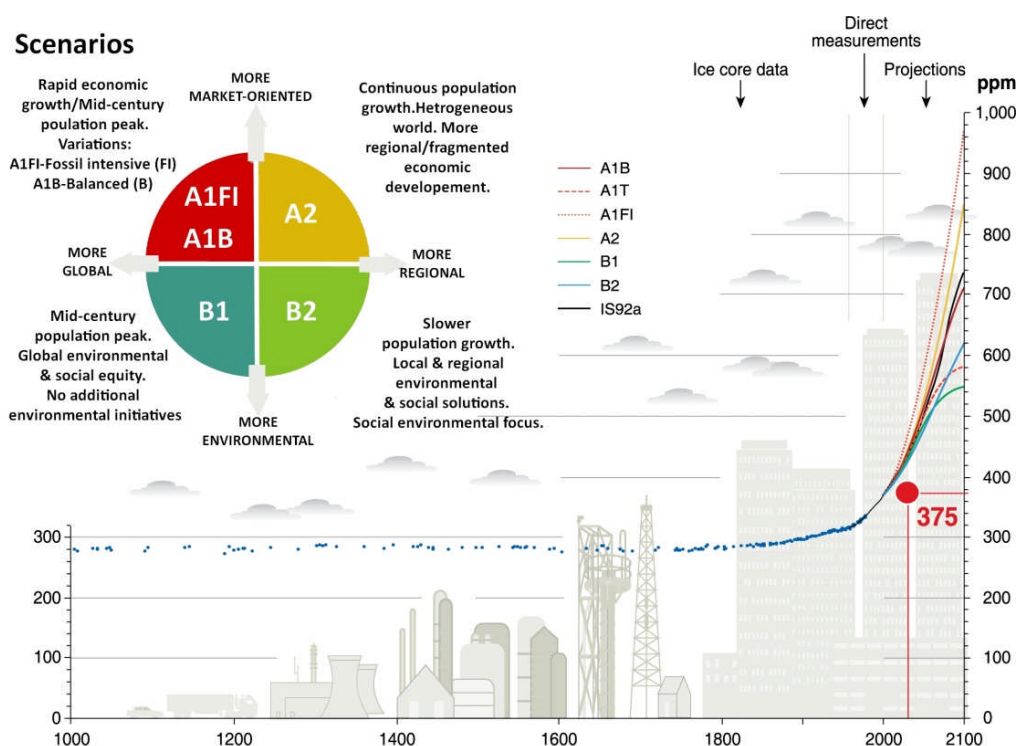


Figure 2.3: Past and future CO<sub>2</sub> concentrations: Future emissions projections are illustrated according to various scenarios with different influences

Source: Adapted from UNEP/GRID-Arendal (P.Rekacewicz, E.Bournay) 2005; IPCC 2001

### 2.1.2-Policy Responses to Climate Change

In recognition of the increased public concern over global environmental issues, a number of international initiatives such as the UN Framework Convention on Climate Change treaty (1992), the Kyoto Protocol to the Framework Convention on Climate Change (1997) (IPCC 2007) and most recently, the efforts of the Copenhagen Accord (2009) have emerged (UNFCCC 2009). The principles laid out in these initiatives have been adopted into the formulation and development of policy instruments for various sectors on both the national and regional scales.

The European Union (EU) has been a leading force in prioritising the formulation of policies in this area. Various initiatives aiming to decrease the 396 ppm CO<sub>2</sub> concentration level of GHGs thought to be produced in EU member states' have been introduced (EEA 2009). The two main types of policy response actions to combat climate change discussed in these initiatives are:

- Adaptation: Where adjustment actions are adopted to deal with the consequences of climate change. This is a selective approach that aims to take advantage of any positive impacts, while reducing the more negative effects of these changes (IPCC 2007; Goklany 2005).
- Mitigation: Where anthropogenic actions are adopted to tackle the causes and reduce all impacts (positive and negative) of climate change (LGA 2010; IPCC 2007).

Although these two approaches have very different characteristics and implementation timescales, they can be adopted in an integrated manner (Figure 2.4) as complementary measures to deal with climate change (IPCC 2007; IPCC 2007a).

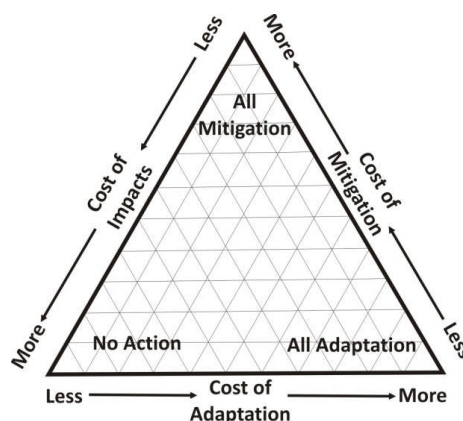


Figure 2.4: A schematic overview of inter-relationships between adaptation, mitigation and impacts  
Source: IPCC 2007- Based on Holeridge 1947,1967

### 2.2-The Environmental Impact of the Building Sector

The built environment is the largest part of the physical and economic manmade capital (Kohler & Yang 2007), where the construction sector itself constitutes a major part of the gross national product (GNP) (Sjöström 2000). In most EU member states, the construction industry alone represents about 11% of the GNP (Lewis 2000).

Energy use in the built environment has been established as a key contributor to anthropogenic climate change (ürge-Vorsatz et al. 2007). The significant increase in energy use recorded in the built environment in recent years is attributable to such factors as population growth, the enhancement of building services, increased comfort levels and the rise in building occupancy periods (Pérez-Lombard et al. 2008).

Figure 2.5 illustrates the complex energy process interactions in buildings. Energy consumption is influenced by various interrelated factors (Al-Homoud 2000). It also occurs in various forms over the five phases that correspond to the building lifecycle (Jones 1998). Consequently, the built environment is considered to be one of the most complex environmental policy target sectors (OECD 2003).

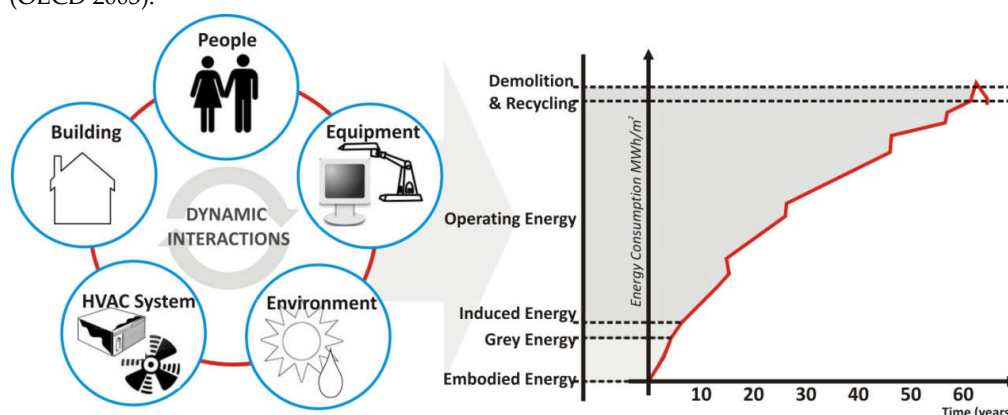


Figure 2.5: Dynamic interacting sub-systems and energy consumption patterns over the lifecycle of a building  
Source: Hensen 2002; Huovila 2007

### 2.2.1-Trends and Future Projections

A review of related data that has become available over the past decade shows that the built environment is responsible for a large share of the world's total energy consumption, accounting for approximately 38% of the total global primary energy use and 25 % of the energy-related CO<sub>2</sub> emissions (de la Rue du Can & Price 2008; Price et al. 2006; Levine et al. 2007; Huovila 2007; Geller & Attali 2005). Studies also indicate that the energy consumption and consequent CO<sub>2</sub> emissions related to the built environment have grown since the 1960s and will continue to do so in the coming years, particularly so in Organisation for Economic Co-operation and Development (OECD)<sup>6</sup> countries (Huovila 2007).

The annual rate of increase of overall building related CO<sub>2</sub> emissions between 1971 and 2004 reported in the latest IPCC Fourth Assessment Report (AR4) was estimated to be 2%. According to the IPCC Special Report on Emissions Scenarios (SRES) (IPCC 2000) future sectoral projections (2000-2030) estimate that emissions will continue to grow at an annual rate of 2.5% in the case of a

<sup>6</sup> An international economic organisation of 30 high-income economies, most of which are regarded as developed countries (OECD 2010).

fuel intensive (A1) development scenario and a considerably lower 1.4% in the more sustainable (B2) development scenario (Price et al. 2006) outlined in Figure 2.3. This significant variation suggests that the promotion of energy efficiency in buildings is a key element in reducing the annual rate of increase of emissions in the sector, and in the wider scope, a critical factor in ensuring a more sustainable future (Sorrell 2003).

### **2.2.2-The Rational for Mitigation in the Built Environment**

The Stern Review (Stern 2007) whose findings have been widely adopted by EU policy-makers and legislators, has made a strong economic case for the adoption of mitigation over adaption options in combating climate change. In the specific context of the built environment, various studies have highlighted the particular potential for applying mitigation options in this economic sector. Two key studies in this field are:

- The global McKinsey abatement cost curve (MACC) for greenhouse gas illustrates the estimated significance and cost of feasible abatement measures in 2030 (Figure 2.6). The MACC highlights that the majority of negative costs lie in the measures associated with the built environment such as the introduction of insulation improvements and the installation of efficient lighting systems (Enkvist et al. 2007).
- The IPCC Fourth Assessment Report (AR4) report (Levine et al. 2007) presents an important body of evidence from a comprehensive survey of 80 studies. This work also highlights the fact that the implementation of the mitigation option in the building sector provides the greatest cost-effective opportunity for considerable reductions in CO<sub>2</sub> emissions, where it is estimated that 30% of the projected global GHG emissions can be avoided by 2030 with net economic benefit (Levine et al. 2007). Furthermore, the report also discusses a wide range of associated co-benefits of mitigation such as improved health, productivity and social welfare of occupants in addition to increased employment opportunities and energy security (Jakob et al. 2006; Mirasgedis et al. 2004; üрге-Vorsatz et al. 2007).

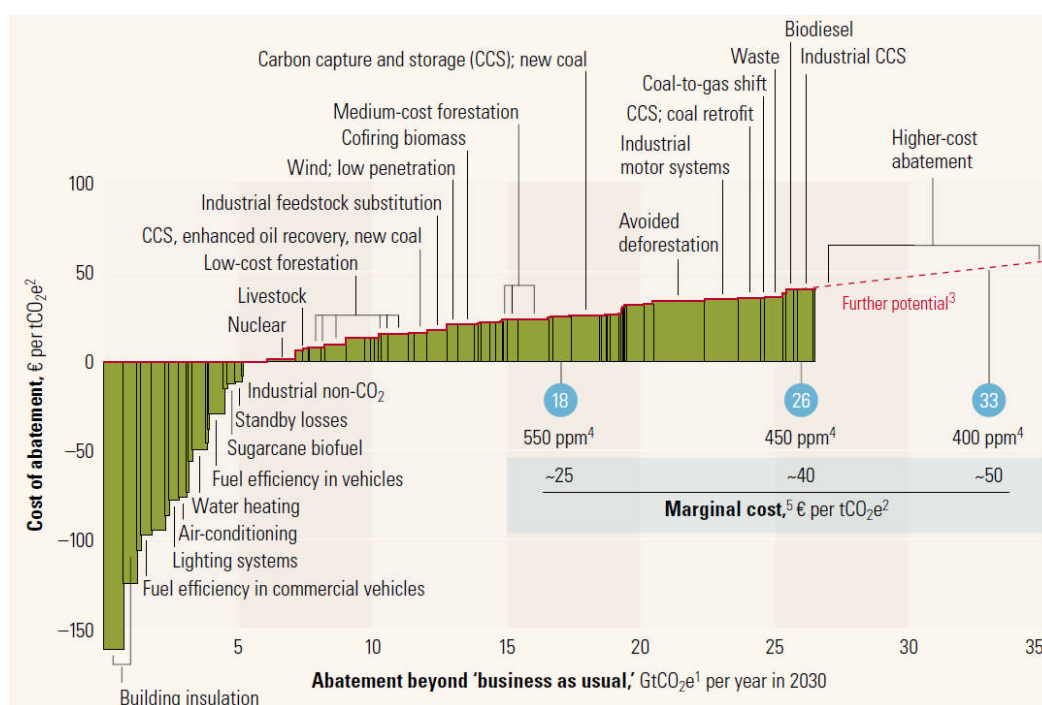
In addition to these inherent benefits, mitigation can also play a vital role in reducing the adaptation challenge (IPCC 2007). This is especially relevant given the fact that the implementation of adaptation actions remains limited while adaptive capacity is being developed (DEFRA 2006b).

One of the key factors that can be considered in the assessment of the potential benefit of adopting mitigation options in the domestic and non-domestic sectors is the emissions growth patterns for each. Studies discussed in the latest IPCC AR4 (Levine et al. 2007) have highlighted two important facts:



- The annual rate of increase of overall building related CO<sub>2</sub> emissions between 1971 and 2004 was estimated to be 2.5 % for the non-domestic sector and 1.7% for the domestic sector.
- The rate of increase of domestic sector CO<sub>2</sub> emissions between 2001 and 2007 increased at a considerably slower rate than the 30-year trend, but those for the non-domestic sector increased at a much faster rate.

In considering that the non-domestic sector has in recent years seen an accelerated annual rate of increase of emissions exceeding that of the domestic sector, it can be concluded that it therefore provides an opportunity where the mitigation approach will be especially relevant and effective. In many countries such as the UK (further discussed in section 4.1.5), the higher replacement and construction rate of the non-domestic sector also provides an increased opportunity for the uptake of mitigation options.



#### Key

<sup>1</sup>GtCO<sub>2</sub>e = gigaton of CO<sub>2</sub> equivalent

'Business as usual' based on emissions growth driven by increasing demand for energy & transport & tropical deforestation.

<sup>2</sup>tCO<sub>2</sub>e = ton of CO<sub>2</sub> equivalent.

<sup>3</sup>Measures costing more than €40 a ton were not considered

<sup>4</sup>Atmospheric concentration of all GHGs recalculated into CO<sub>2</sub> equivalents

<sup>5</sup>Marginal cost of avoiding emissions of 1 ton of CO<sub>2</sub> equivalents in each abatement demand scenario

Figure 2.6: Global cost curve for greenhouse gas abatement measures beyond 'business as usual'  
Source: Enkvist et al. 2007

### 2.2.3-Policy Instruments for the Implementation of Mitigation Options

The implementation of mitigation measures involves the use of options that can vary significantly between economic sectors. These options include economic instruments, information efforts, technical standards and other policies and measures (IPCC 2007b). In the built environment, the main options can be broadly categorised as:

- Technical options: Which include a wide array of energy efficient design practices and technology-based approaches. Despite their effectiveness, it has been recognised that such factors as financial hurdles, hidden costs and benefits, market failures and behavioural constraints often inhibit their uptake (ürge-Vorsatz et al. 2007; Carbon Trust 2005).
- Policy options: Key policy instruments can be categorised according to a typology adapted by ürge-Vorsatz et al. (2007). These include control and regulatory instruments, economic/market-based instruments, financial instruments/incentives, and support, information and voluntary action (e.g. Verbruggen & Bongaerts 2003; Crossley et al. 2000; Grubb 1991).

There is a general consensus by most energy analysts and economists (Varone & Aebischer 2001) that the state should have an active role in the promotion of energy efficiency through the use of the wide range of policy options. These can play a vital role in reducing or eliminating the barriers that inhibit the uptake of technical options (Brown 2001) and are considered to be the main vehicle for settling conflicts of interests between the various parties involved in the construction market (Becker 2005).

This view is supported by the Stern Review (Stern 2007), which advocates the opinion that the use of regulatory instruments in the form of standards and regulations can provide powerful and effective policies to promote action on mitigation by decreasing associated complexities, providing clarity and offering a high level of certainty (Shipworth 2007). However, it should be noted that the application of regulation involves certain risks (e.g. poor implementation or enforcement) that can cause regulatory failure, the effect of which can exceed that of any market-based failure it was introduced to address (BRC 2004; BRC 2003).

Whilst a variety of government-based measures have been demonstrated to be successful in many countries (Levine et al. 2007), the enforcement of strong policy intervention through the use of control and regulatory instruments (Table 2.1) has in particular been shown to have a significant effect in the mitigation of GHG emissions in the built environment (Wiel et al. 1998).

Table 2.1: The impact and effectiveness of various control and regulatory mechanism policy instruments aimed at built environment GHG emissions mitigation  
Source: Levine et al. 2007

Policy instrument	Effectiveness	Cost-effectiveness	Special conditions for success, major strengths & limitations, co-benefits
<b>Appliance standards</b>	High	High	Success factors include periodical update of standards, independent control, information, communication & education.
<b>Building codes</b>	High	Medium	Provides no incentive to improve beyond target. Only effective if enforced.
<b>Procurement regulations</b>	High	Medium	Success factors include enabling legislation, energy efficiency labelling & testing, ambitious energy efficiency specifications.
<b>Mandatory labelling &amp; Certification programs</b>	High	High	Effectiveness can be boosted by combination with other instruments and regular updates.
<b>Energy efficiency obligations and quotas</b>	High	High	Continuous improvements in the form of new energy efficiency measures, short-term incentives to transform markets...etc. are necessary.
<b>Utility demand side management programs</b>	High	High	The programmes tend to be more cost effective for non-domestic sectors than for the domestic sector.

## 2.3-Regulatory Policies in the Built Environment

Regulatory systems consist of a series of legally enforceable rules that aim to establish a degree of control and allow governmental intervention over various socio-economic activities (Salembier 2002). These 'rules' have been employed as the primary means to intervene in the market to achieve positive changes to the social, economic or environmental gains in societies (Lee & Yik 2004). In the built environment, regulations embody public expectation as to how buildings and facilities are expected to perform (Bukowski 2002) and aim to ensure that they provide adequate levels of health, safety, welfare and amenity for both occupants and the wider community (Meacham et al. 2005).

### 2.3.1-History of Building Regulations

The set of codes produced during the reign of Hammurabi over Babylon (1955-1913 BC) (Horne 2007 from Hermann & Johns 1910) are cited as the first instance of the use of regulations to govern the practice of construction (Figure 2.7). The development of building regulations summarised in Table 2.2 illustrates the shift of focus in regulatory intent (the purpose for which regulations are formulated and enforced) that has occurred over time. During the era of the rapid growth of the Roman Empire, laws were issued to limit building height and avert collapse (Cote & Grant 2003). The main driver for the standards that were mandated in various European and North American cities such as London and Boston was the prevention of devastating fires and alleviation of poor living conditions (Greenstreet 1996; Cote & Grant 2003; Vale & Campanella 2005).

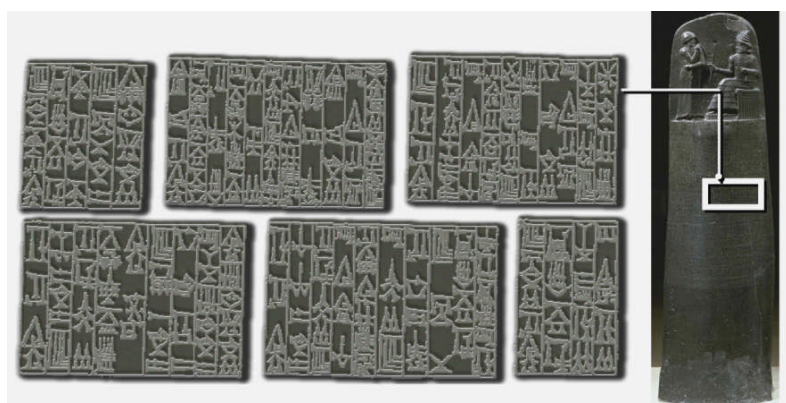


Figure 2.7: Hammurabi's Code, from an engraving on a Stele in the Louvre, Paris

Source: Sobhy 2005, Adapted from Gero 1996

From the industrial era until second half of the twentieth century, the prescriptive-based approach was adopted as the prime instrument for controlling the standard of construction relative to safety, fire prevention and sanitation (Lucht 1999). In this system, a set of minimum requirements or processes was 'prescribed' in associated documentation. These were to be strictly adhered to for the related regulatory goal to be achieved. While theoretically simple and straightforward, prescriptive-based regulations severely limited the available solutions for compliance and were therefore largely restrictive and inhibitive to the development of new materials and construction methods (Pilzer 2005).

Table 2.2: The development of building regulations: controls, issues and proponents

Source: Cote & Grant 2003

	Era	Control	Issues	Proponent
<b>1955-1913 B.C</b>	Babylonian Civilisation	Hammurabi's Code Articles 228-233	Structural Failure	Building collapse
<b>90-50 B.C</b>	Roman Empire	Building Height Restrictions		Apartment building collapse
<b>1666 A.D</b>	Western Civilisation	Fire Control Acts (e.g. 1667 London Building Act, NBFU Standards 1866)	Fire hazards	City fires (e.g. London 1666)
<b>1875 A.D</b>	Industrial Revolution	Health Acts (e.g. London Public Health Act 1875 New York Tenement House Act 1901)	Public health & welfare	Urban expansion Disease outbreak
<b>1950 A.D</b>	Twentieth Century	Performance-based regulations & energy policies	User needs Environmental \ Energy Issues	Energy Crisis Kyoto Protocol

### 2.3.2-The Development of the Performance Framework

The rapid rate of advance in building technologies and design techniques that occurred over the latter part of the twentieth century resulted in a strong interest in developing and implementing a revised goal-oriented regulatory system. This interest was fuelled by the need to address the difficult task of reconciling societal goals (Meacham et al. 2005) such as higher user expectations of building performance (Foliente 2000) with the increased interest in environmental consciousnesses, energy security and the promotion of energy efficiency (Barlow & Bhatti 1997; Janssen 2004).

Consequently, throughout the 1960s and early 1970s, numerous worldwide activities were undertaken in an attempt to develop methodologies and tools for the application of the performance-based building approach (PBB) (Gross 1997; Lee & Barrett 2003). This approach moves away from prescribed requirements to the practice of “*thinking and working in ends rather than means*” (Gibson 1982, p.2), where only performance goals are specified and flexibility in the selection of the materials and processes utilised to achieve them is allowed (Thomas 2003; Sorrell 2003).

Most performance-based regulatory models are based on the Nordic Five-Tier System. In this model (illustrated in Figure 2.8), the top three levels represent the mandatory performance goals and the last two describe the method(s) by which compliance can be achieved (NKB 1978). Key performance indicators are used to provide simple yet coherent criteria that set the acceptable level or range of performance parameters. Tools at the disposal of the regulatory community can then be used to verify compliance of solutions with specified performance requirements (Becker 2005).

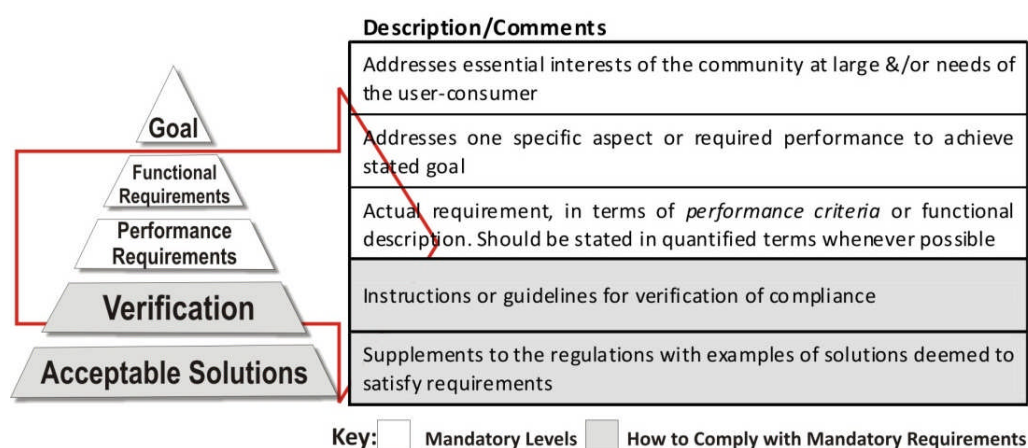
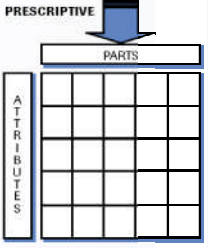
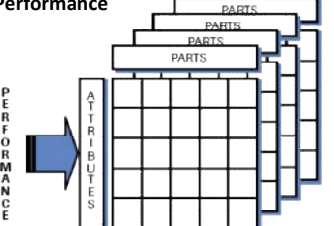


Figure 2.8: Representation of Nordic Five-Tier System and level descriptions  
Source: Meacham et al. 2005; Watermeyer & Millford 2003

Various advantages associated with this approach include increased design flexibility and the encouragement of technological innovation (Table 2.3). Wider legislative advantages include the downsizing of government, deregulation and the provision of internationally credible standards (Watermeyer & Millford 2003; Coglianese et al. 2002).

Table 2.3: Prescriptive versus Performance: Main features of regulatory approaches in the built environment  
Source: Olivier 2008; Foliente 2000

Approach		Advantages	Disadvantages
Prescriptive		<ul style="list-style-type: none"> <li>• Simple &amp; straightforward</li> <li>• Easy to administer &amp; enforce.</li> <li>• In principle, requires a few experts to implement.</li> <li>• No compromise in fabric standards as the result of trade-offs against more sophisticated HVAC.</li> </ul>	<ul style="list-style-type: none"> <li>• Inflexible/limited compliance options</li> <li>• Inhibitive to innovation &amp; developments.</li> <li>• Difficult to cost-optimize building construction.</li> </ul>
Performance		<ul style="list-style-type: none"> <li>• Few or no restrictions on the means to achieve compliance objectives.</li> <li>• Gives designers increased freedom to devise the 'best' solution.</li> <li>• In principle, could reduce costs.</li> </ul>	<ul style="list-style-type: none"> <li>• Complex for designers to deal with.</li> <li>• Pre-supposes a highly-educated, well-informed industry.</li> <li>• Subject to errors.</li> <li>• Performance goals may not be achieved in practice or may affect building envelope fabric standards.</li> </ul>

## 2.4-Energy Efficiency as a Regulatory Performance Goal

The specific definition of 'building performance' as a whole is a complex one (Cole 1998) involving the consideration of various factors associated with the areas of architecture, environmental engineering, user comfort conditions, whole-life costs and user satisfaction (Cook 2007). The implementation of a PBB environment can provide an effective framework to holistically assess these factors and consequently achieve improvement in the general performance-in-use of buildings (Becker 2005).

Energy efficiency is considered a key domain in a performance-based approach. As a performance category, it describes and assesses the building's features and characteristics relevant to its impact on the environment and considers the effects on both the local and global environment (Lützkendorf et al. 2005). The energy performance of a building can be defined as "the amount of energy actually consumed or estimated to meet the different needs associated with a standardised use" (EEA n.d.).

The control of the energy performance of buildings and the promotion of the uptake of energy efficient technologies through regulatory control came into prominence in the mid 1970s (Lee & Yik 2004). Since energy efficiency is one of the most cost-effective approaches to achieving emissions reductions (Figueres & Phillips 2007), it has consequently become a priority in the development of new building regulations (Pérez-Lombard et al. 2008). In general, energy efficiency legislation in the built environment is enforced to achieve *demand-side*<sup>7</sup> emissions reductions through three main approaches (Janssen 2004):

<sup>7</sup> Emissions reductions can be categorised as either supply-side (i.e. sourcing energy from alternative 'clean' sources) or demand-side (i.e. measures that reduce actual energy demand) (Tanatvanit et al. 2004).

- Upgrading existing buildings to reduce energy consumption, since older buildings tend to be less energy-efficient than modern best practice.
- Ensuring new buildings are constructed according to higher standards of thermal quality, since building energy efficiency into the design and construction is more economic than through retrofit.
- Modifying occupant behaviour to promote the rational use of energy through increasing awareness of how energy is used and encouraging the elimination of wasteful practices.

In extending this into the regulatory context, energy performance goals such as energy consumption levels or resulting emissions can be determined. This ensures that all parties concerned are aware of the associated requirements and that a certain minimum level of performance is achieved (Figure 2.9). The approach can effectively encourage more widespread uptake of energy efficient measures, the consideration of energy performance from the earliest design stages and innovation in the use of new energy efficient technologies.

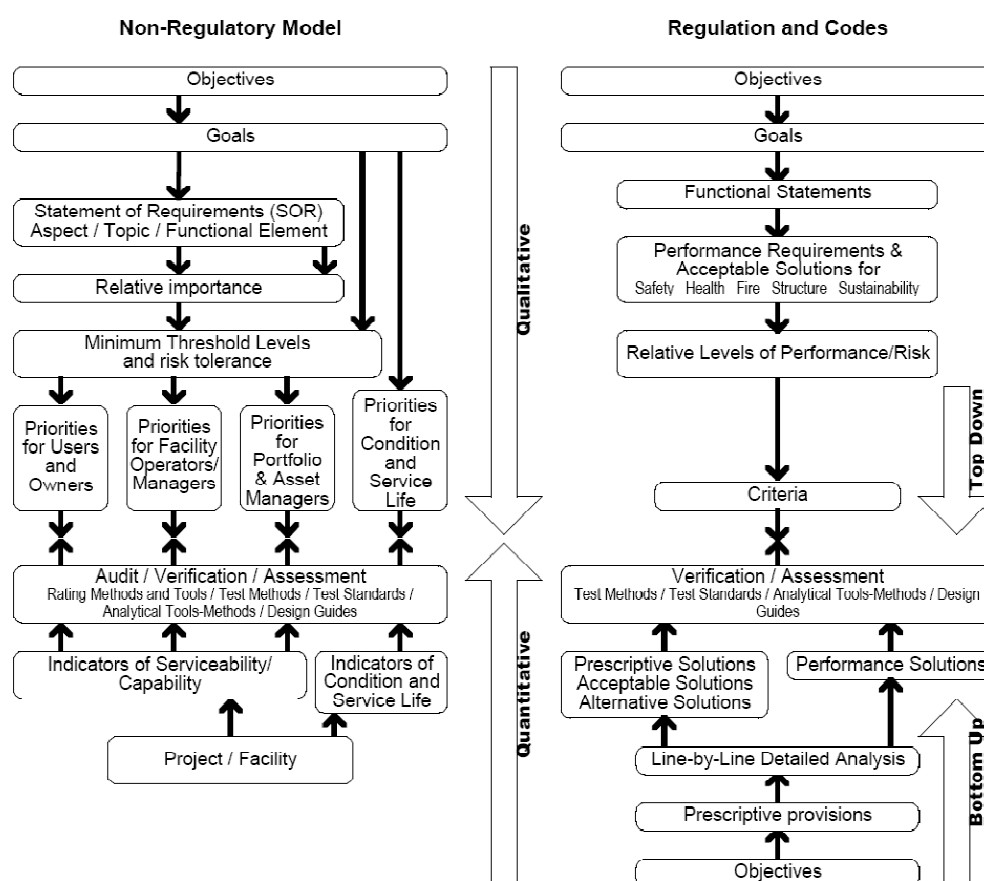


Figure 2.9: The performance system model showing both non-regulatory and regulatory requirements  
Source: Szigei & Davis 2001

### 2.4.1-Energy Performance in National Codes

Various countries such as the UK (1985) and New Zealand (1992) have led the way in embracing the transition from a prescriptive to a performance framework in the formulation of building regulations (Lützkendorf et al. 2005). In recognition of the particular benefits it provides in the promotion of energy efficiency, a number of national building codes around the world (Figure 2.10) now include energy performance standards (e.g. Huovila 2007; Hitchin 2008; Janda 2009). These standards have various objectives that include conserving fuel, decreasing energy consumption and reducing GHG (in particular CO<sub>2</sub>) emissions (Parsons 2004).

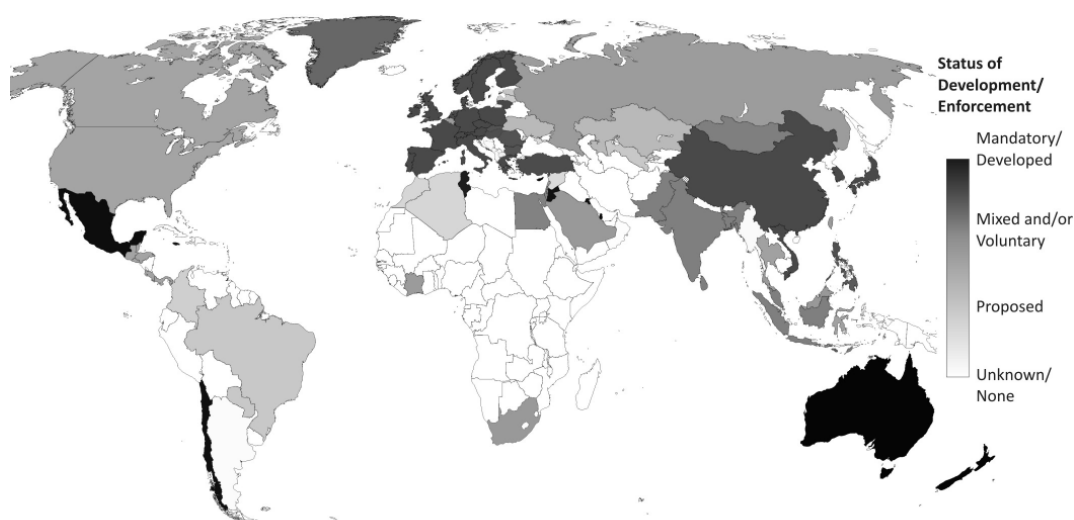


Figure 2.10: Status of energy efficiency building standards  
Source: Adapted from Huovila 2007; Hitchin 2008; Janda 2009

#### Chapter Summary

- Scientific evidence that has been accumulating over recent decades has made a strong case for anthropogenic climate interference, which is the 'forcing' that can be attributed to human related activities.
- As the most significant anthropogenic GHG, CO<sub>2</sub> has been widely adopted as the primary indicator of the magnitude of climate change, and stabilisation target levels have been recommended accordingly.
- Energy use in the built environment is a key contributor to anthropogenic climate change, where the implementation of the mitigation option represents the greatest opportunity for considerable reductions in CO<sub>2</sub> emissions.



- The enforcement of strong policy intervention utilising control and regulatory instruments has in particular been shown to have a significant effect in this field.
- Energy performance standards have become a priority in the development of new building legislation and are a key domain in implementing a performance-based approach to regulation.
- Various countries have adopted energy performance standards into their national building code.

## Chapter 3: Predicting Building Performance- Methods and Tools

*For a performance-based regulatory system a method by which to assess and verify the performance of a proposed solution is a fundamental aspect in ensuring the applicability of the approach. The following chapter explores the area of applied computation in building design assessment. The basic concepts and principles of building energy performance prediction are outlined and the modelling-based building energy performance prediction (BEPP) tools which have developed over the past quarter of a century to undertake building design analysis and appraisals are discussed. Associated barriers to uptake and issues in implementation are highlighted*

### 3.1-Performance Prediction and Assessment

One of the main challenges associated with the decision-making process involved in the performance-based approach (Figure 3.1) is how to predict and assess the performance of a building based on a proposed design (Spekkink 2004). Performance *prediction* involves the development of models that attempt to replicate or account for the interactions within a building and estimate its future behaviour, while performance *assessment* involves the evaluation of predicted performance based on the knowledge of what is desired and what is possible (Papamichael 2000).

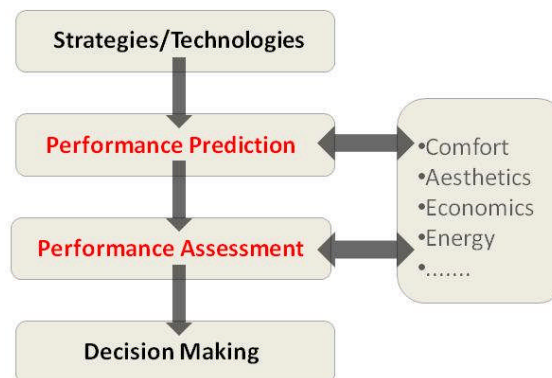


Figure 3.1: Decision-making requires performance prediction as well as performance assessment with respect to multiple performance considerations.

Source: Papamichael et al. 1997

Building energy performance prediction is considered to be “the science of estimating the energy interactions within a building” (IISBE 2005). As discussed, a number of interrelated issues influence building design (Al-Homoud 2000), and consequently its energy performance. It is only by taking into account the dynamic interactions of these factors that a complete understanding of building behaviour can be obtained (Hensen 2001).

### 3.1.1-Performance Prediction and Assessment for Building Energy Compliance Verification

The demand for building assessment results has expanded beyond what was originally a predominantly scientific interest (Lützkendorf & Lorenz 2006) and is now becoming commonplace in the feedback for energy efficient design (Chirarattananon & Taveekun 2004; Elrick 2006). In particular, it is in the application of performance-based regulations that the concepts of prediction and assessment have become a fundamental aspect in the verification of building energy performance compliance (Hensen & Nakahara 2001; Pilzer 2005).

This relationship is evident in the legislative call for the integration of the use of building energy performance prediction tools that has accompanied the international shift from prescriptive to performance-based regulations. In this context, performance assessment refers to the identification and quantification of the performance objectives through key indicators that provide simple yet coherent criteria that a building is expected to satisfy. Following this, objective and rigorous means of systematic assessment using methods and tools that are available to the regulatory community are then utilised to predict performance and verify compliance against these performance targets (Gursel et al. 2009; Becker 2005; Foliente et al. 1998).

### 3.1.2-Overview of Assessment Approaches

De Wilde (2004) identifies three main approaches to assessing the performance of buildings:

- **Monitoring/Measurement:** The direct observation of the behaviour of real buildings under operational conditions.
- **Experimental set-up/Testing:** The measurement of the behaviour of a building component or part constructed and tested under experimental conditions.
- **Computational assessment:** The (re)production of building behaviour - often within a virtual environment - using mathematical equations.

With regard to the process of compliance verification (Figure 3.2), the application of monitoring is not viable since it is in essence retrospective, therefore only the last two approaches can be considered (Foliente 2000; Hunt & Cheers 2005). Ruppert's Law (Figure 3.3) considers the relationship between the last two options, and states that (depending on time and problem complexity) the costs associated with physical experimentation are much higher than those for computational assessment (Hensen & Djunaedy 2005). In view of the complex interactions between each particular building and its specific components, additional limitations are imposed on the transferability of the results of experimental testing, computational assessment therefore emerges as the only option that allows accurate and cost-effective prediction of the behaviour of an unrealised building (de Wilde 2004).

The adoption of universal verification methods can simplify conformity within assessment procedures for trade between countries with a performance-based system and a common regulatory structure (Hunt & Cheers 2005). However, in the area of building energy efficiency, verification methods are yet to be standardised, therefore vital development efforts are continually being made to provide the infrastructure for such standardisation (Becker 2005).

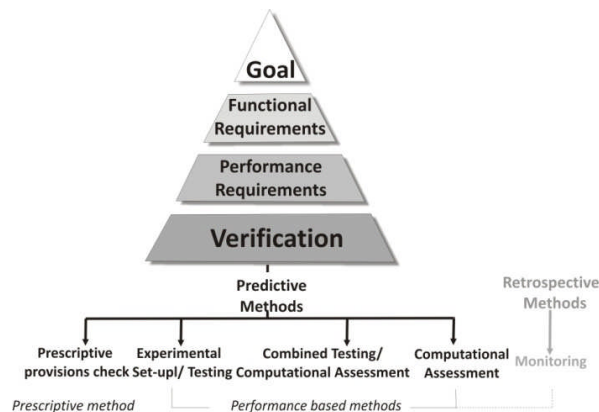


Figure 3.2: Verification methods for the performance approach  
Source: Adapted from Foliente 2000

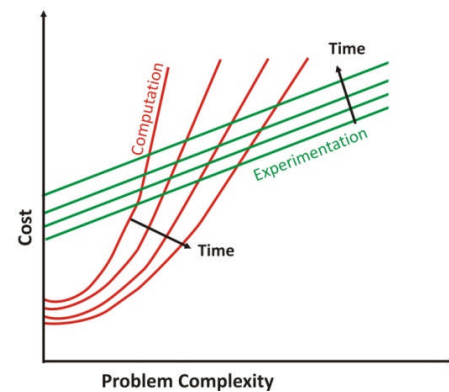


Figure 3.3: Ruppert's Law  
Source: Hensen & Djunaedy 2005

### 3.2-Concepts of Building Energy Performance

The prediction and assessment of building energy performance involves the analysis of the complex energy-related interactions to predict energy demand and consumption patterns of a proposed design (Becker 2005). Design changes that provide incremental improvements, measured against criteria such as reduced energy consumption and/or improved thermal comfort (Soebarto & Williamson 1999) can then be explored and selected for implementation where most appropriate and cost-effective.

A variety of methods have been employed in the various building performance categories. The use of integrated computer tools that use mathematical data models enable the holistic modelling and simulation of certain in-use behavioural aspects of the building. Given the increasing complexity of energy/environmental systems, the use of these tools is emerging as the most viable approach to design and performance evaluation in the field of energy performance assessment.

It is important to establish and differentiate between the central concepts that are involved with energy performance prediction. In relevant literature, the terms associated with these concepts are often used interchangeably. However, in this research they are defined as follows:

### 3.2.1-Modelling

Modelling can be described as the process of developing a model that faithfully represents a complex system (Hensen 1994), of which buildings are one type. A classification scheme for models proposed by Page (1994) distinguishes various dimensions of characterisation and accordingly lists several typologies which are listed in Table 3.1.

Table 3.1: Model typology classification scheme  
Source: Page 1994

Dimension of characterisation	Type	Description
<b>A Model representation</b>	<i>Abstract Model</i>	The model is represented through symbols. This may either involve a verbal/written description or a mathematical model that is described in the symbology of mathematics.
	<i>Physical Model</i>	This uses scaled replica representations of the system & may also be referred to as an iconic model.
<b>B The study objective underlying the model</b>	<i>Descriptive Model</i>	Describes the behaviour of a system without any value judgement on the quality of such behaviour.
	<i>Prescriptive (normative) Model</i>	Describes the behaviour of a system in terms of the quality of such behaviour. When solved, these models provide a description of the solution as optimal, suboptimal, feasible, infeasible...etc.
<b>C Temporal properties in the model</b>	<i>Static Model</i>	Describes relationships that do not change with respect to time & may be either abstract or physical.
	<i>Dynamic Model</i>	Describes time-varying relationships.
<b>D The solution technique</b>	<i>Analytical Model</i>	Provides closed-form solutions using formal reasoning techniques, such as mathematical deduction.
	<i>Numerical Model</i>	Solved by applying computational procedures, may also be referred to computational/mathematical models.

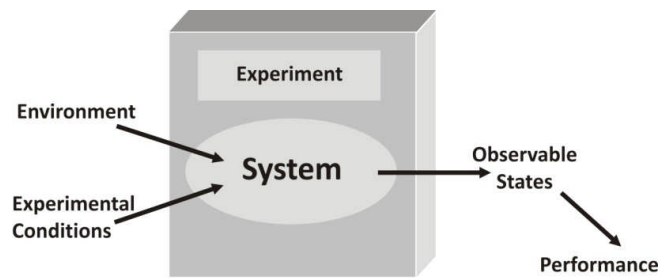
In the realm of energy performance prediction, buildings are most often represented as abstract models (which are either static or dynamic) to which numerical solution techniques are applied. In this specific context, since mathematical procedures based on the concepts of building physics are applied to the models, they are also often referred to as *physical* models (Page 1994).

### 3.2.2-Calculation

In its general sense, calculation is the deliberate process of transforming one or more inputs into one or more results, with variable change. The term is used in a variety of senses, in this study it is used to denote the implementation of simplified arithmetical computational procedures (algorithms) that aim to represent the buildings interactions and, consequently, produce predictive outputs (results).

### 3.2.3-Simulation

A definition of simulation synthesised from relevant literature describes it as “a virtual experiment that involves the reproduction of the physical behaviour of a system to create a virtual abstracted equivalent behavioural model of the building and provide transient simulations of energy transfers within it” (de Wilde 2004; Augenbroe et al. 2004; Augenbroe 2002; Morbitzer 2003). Simulation can therefore in general be considered an analytical and predictive process that attempts to emulate future reality of the behaviour of a building (Hensen 1994) (Figure 3.4).

**Experiment Manifestations:**

- Real: Scale model or real thing
- Virtual: Simulation model in computer memory
- Hybrid: Augmented reality (both real and virtual)

Figure 3.4: Simulation viewed as a virtual experiment

Source: Augenbroe 2004

In the context of building energy performance simulation, the main components of this process are defined as (de Wilde 2004; Crawley et al. 2005):

- Input parameters: Data used to describe/define the system being simulated (the building) and create a simplified virtual model representing it.
- Model: As previously discussed, the term 'model' predominantly refers to the abstract numerical model used to represent the physical processes in the actual (proposed) building.
- Simulation algorithms: The computational procedures or methodology that is implemented.
- Simulation tool: The software environment which acts as the "vehicle that enables the methodology to be applied" (Doyle 2008, p.66).
- Outputs/results: The outcomes of the simulation that describe the predicted energy interactions.

### 3.3-Computer-Based Building Energy Performance Prediction Tools

The use of computer-based applications was first introduced into architectural, engineering and construction practices in the early 1960s in the form of Computer-Aided Design (CAD) technology (Kusada 1999). The energy crisis of the 1970s resulted in the increased importance of building system energy issues. The consequent efforts to understand these issues and facilitate the development of energy efficient strategies and technologies, in turn, led to the development of several (relatively simplified) computer-based building energy performance prediction tools (Papamichael 2000). Over the past two decades, as discussed in the following section, this discipline has matured into a field that offers unique expertise, methods and tools for building performance assessment (Hensen & Augenbroe 2004).

### 3.3.1-Evolution of Building Energy Performance Prediction Tools

Since careful long-term decisions in the design and operation of buildings can significantly improve their energy efficiency, various energy performance prediction methods (de Wilde 2004; Crawley et al. 2005) were developed to facilitate the objective assessment of design proposals and support the decision-making process for energy efficient design (Morbiter 2003). As building energy and environmental systems increased in complexity, these tools evolved from basic rules and design guidelines that provided general advice and benchmarks to hand calculations that were predominantly used in load estimation and equipment sizing applications (Table 3.2).

Table 3.2: Energy and environmental design decision support tools  
Source: Hensen & Augenbroe 2004

	Method/Tool	Description	Examples
Increased degree of sophistication ↓	<b>Design Guidelines or Rules of Thumb</b>	Does not predict performance but gives general design advice on reaching performance targets.	BRECSU 77/98 Software
	<b>Traditional Physical Calculation Methods</b>	Focuses on a limited number, often only one, of physical phenomena in a building.	Energy Efficiency Best Practice Programme JPA-U value
	<b>Correlation-Based Methods</b>	Attempts to consider all physical aspects influencing performance; restrictions in design specifications & performance assessments.	BRE Environmental Design Guide for Naturally Ventilated & Daylit Offices
	<b>Building (Energy) Performance Modelling, Calculation and Simulation</b>	Creation of a virtual building where detailed parameters influencing performance can be specified, predictions are highly accurate.	ESP-r Radiance

As developments in the design and construction process led to an increased demand for more accurate and increasingly complex calculation capabilities, coincident developments in computing facilities led to an emergent interest in the development of more sophisticated computer-based tools, which were initially used for research purposes. In the 1980s and early 1990s, the decrease in the cost of computing power resulted in the introduction of PC-based versions of these tools (Papamichael 2000), which can collectively be referred to as building energy performance prediction (BEPP) tools.

This marked evolution of development and uptake of BEPP tools – the ‘evolutionary process’ – was summarised by Clarke (2001) over four generations. As illustrated in Figure 3.5, each of these generations marked a shift towards the use of more realistic input data and user-friendly interfaces, an increased ability to more accurately predict building heat transfer mechanisms, and consequently, an increased transferability of results (Morbiter 2003). Efforts to increase the usability of this technology have not only lead to a more widespread use in the design process (Yezioro et al. 2008), but have also resulted in a greater understanding of the associated limitations, and as a consequence, a more realistic level of expectation of its potential (Hensen 2002).

- **First Generation:** These were simple handbook orientated computer applications. Rather than aiming to accurately represent the energy and mass flow paths that occur in a real building, these tools aimed to provide general indications of certain building performance criteria (Morbiter 2003). Clarke (2001) states that these tools were easy to use but had deficiencies that limited the translation of results they produced to 'real world' applications.
- **Second Generation:** Introduced in the mid 1970s, these tools aimed to account for the dynamic interactions within buildings by attempting to imitate the real physical conditions within it through the incorporation of more realistic data and a more complex software structure. Due to limitations in the computational interface, early versions were not utilised in the design process (Hand 1998).
- **Third Generation:** With the introduction of more powerful PCs in the mid 1980s, multi-functional integrated tools that linked all system parameters were developed. As only space and time were considered independent variables, all other dependant parameters were taken into account when calculating any single energy or mass transfer process, leading to the facilitation of the combined assessment of various processes.
- **Fourth Generation:** These tools emerged in the 1990s in response to the growing use by building designers and involved both further domain integration and program interoperability. They offered more accessible user interfaces, application quality control (Hand 1998) and user training (CIBSE 1998). However, users with a limited background in energy and environmental aspects of building design often faced difficulties in operating them. Since these programs relied on both realistic data and multi-variant parameter analysis, they were able to produce significantly more comprehensive and accurate information than any of their predecessors (Morbiter 2003).

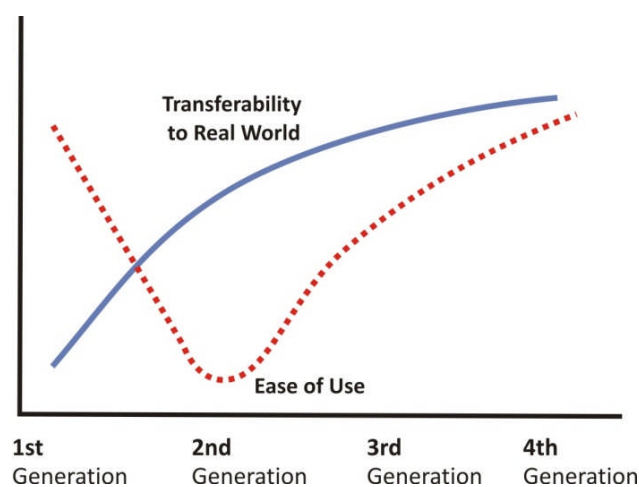


Figure 3.5: Generational development in computer-based energy performance prediction tools  
Source: Hensen & Augenbroe 2004



### 3.3.2-Calculation Methodologies of Modelling-Based Tools

A 'method' denotes the generic basis for systematic and purposive proceeding (Lützkendorf & Lorenz 2006), for building energy performance prediction these range from simplified to fully comprehensive (Doyle 2008). Hensen (1994) describes the difference between these methods being that while simplified approaches attempt to generate an exact solution of an approximation of the real problem, comprehensive methods attempt to approximate a solution of an 'exact' representation of the problem. Schlueter and Thesseling (2009) differentiate between two main typologies, where:

- *Static calculation methods* employ an abstract simplified approach for the estimation of the total heating/cooling or lighting energy demand. These tools are typically spreadsheet or web-based applications that provide approximations that are often used for indicative studies or in a regulatory context.
- *Modelling-based methods* employ virtual 'physical models' to calculate the physical processes within the building. These methods are more complex and can be used for a wider scope of regulatory, design and analysis applications.

The main calculation methods concerning modelling-based approaches can be described as follows:

#### 3.3.2.1-Simplified Modelling Methods

Simplified modelling involves the use of a virtual physical model and the application of calculation procedures that involve averaging the internal and external factors that affect the energy performance of a building (Doyle 2008; Hensen 1994). The term 'simplified' denotes that certain assumptions are applied to the underlying model, where some energy or mass flow paths that interact in a dynamic fashion may either be approximated or entirely omitted (Hensen 1994).

Tools that fall under this category may use any of the simplified modelling approaches such as the simple degree-day method, developed degree-day method or the monthly heat balance (utilisation factor) method (Hitchin 2005). In these cases, steady-state models that average variables over a longer period (monthly, seasonally or annually) where all building parameters are fixed are used (Busch 1996).

The two main concerns associated with simplified methods relate to their ability in representing the complexities of HVAC systems and the soundness and reliability of results when various (and sometimes important) energy related aspects are not fully accounted for, and may therefore require some sort of 'adjustment' in order to account for them (Hensen 1994; Hitchin 2005). Due to the implicit limitations of this approach, it is important to recognise that a degree of predictive risk is associated with this option (Beattie & Ward 1999).

Modifications to the simplified approach that aim to address the previous concerns to a certain extent include the use of quasi steady-state models. These account for the effect of some transient parameters such as the weather and can be used to establish more accurate predictions concerning building performance (Kim & Kim 2007). A further modification, the simplified dynamic method, is described in the CEN draft standards and can be used to better represent the complexities of HVAC systems performance. Here, the input data required is similar to that used for monthly calculations, however shorter (typically hourly) time steps calculations using appropriate weather and operational data are performed (Hitchin 2005a).

Since computer programs that use any of the aforementioned simplified modelling methods do not aim to take all the complex interactions of the building into account and therefore do not attempt to 'simulate' it, they are therefore often referred to as 'calculation tools'.

### ***3.3.2.2-Complex Dynamic Simulation Methods***

The second modelling-based method involves the implementation of complex and iterative predictive (typically hourly) analytical procedures (Doyle 2008). The tools that use this approach enable the study of transient responses of a building and its energy systems to the climate (Thomas 2002) and allow for the specification of detailed parameters that influence building performance. The virtual models created in this case form complex data structures that are often difficult to comprehend, therefore tools generally employ a graphical interface that visually represents the building and aids the user's understanding of the underlying structure and content (Gursel et al. 2009). As a specific subset of BEPP tools, software tools that fall under this category are often referred to as 'simulation tools'.

This approach is generally considered to be more realistic and more widely applicable, since it provides the capability of creating virtual models of more complex buildings and more accurately simulates the interaction of the physical processes that occur within them. The approach also allows the prediction and objective assessment of the overall energy performance of design proposals (e.g. de Wilde 2004; Crawley et al. 2005) with the relatively high degree of accuracy required by stringent energy policies (Bleil de Souza et al. 2006). The main differences between the two main modelling-based approaches used in building energy performance prediction are summarised in Table 3.3.

Table 3.3: Comparison of the main calculation methods used in building energy performance prediction

	Simple	Complex
	← 'Calculation Tools'	'Simulation Tools' →
<b>Function</b>	<b>Indicative - Evaluation</b>	<b>Deterministic - Design/Analysis</b>
<b>Description</b>	Steady-state/quasi steady-state models Average annual/monthly calculation Averaged variables/fixed parameters	Complex & iterative predictive procedures Detailed hourly calculation Dynamic/transient parameters
<b>Advantages</b>	Fast & simple Less computing power Low cost	More accurate & realistic Less 'fudge factors' Detailed specification
<b>Disadvantages</b>	Technical limitations Less accurate Ignores complex building interactions Limited information	Slow calculation/execution speed Complexity High development & retail costs

### 3.3.3-Overview of Building Energy Performance Prediction Tools

Clarke (1997, p.1) states that the advantage of the use of computer-based BEPP tools lies in the fact that the process “permits an evaluation of building performance in a manner that corresponds to reality [...] and enables integrated performance assessment in which no single issue is unduly prominent”. Hand (1998) has discussed the applicability of modelling studies to address a range of questions related to such aspects as conformance to performance-based standards, the support of novel designs, best practice and research applications. The advantages associated with the application of these studies have been widely discussed in relevant literature; some examples of this can be listed as follows:

- The encouragement of new design concepts and strategies through the evaluation and development of appropriate hardware components (e.g. CIBSE 1998; Hand 1998).
- The improvement of the environmental performance of buildings through the provision of an effective mechanism for optimising internal environmental conditions (CIBSE 1998).
- The facilitation of the application of a holistic approach to assessing the overall performance of design proposals (e.g. Hensen & Nakahara 2001; de Wilde 2004; Crawley et al. 2005; Spekkink 2005a)
- The support of the exploration of innovative approaches to satisfying performance requirements (e.g. BCA 2004; Strachan 2008).

Consequently, following the early advances of tools described by Judkoff et al (2008) (Figure 3.6) development efforts in this field have been considerable. A comprehensive database of these tools (USDOE 2010) estimates that over 360 tools are currently available for various energy prediction and environmental design purposes. A number of studies in this field have been conducted over the years, the most comprehensive of which (Crawley et al. 2005) discusses 20 of the most popular publically available tools, outlining their capabilities and limitations (Table 3.4).

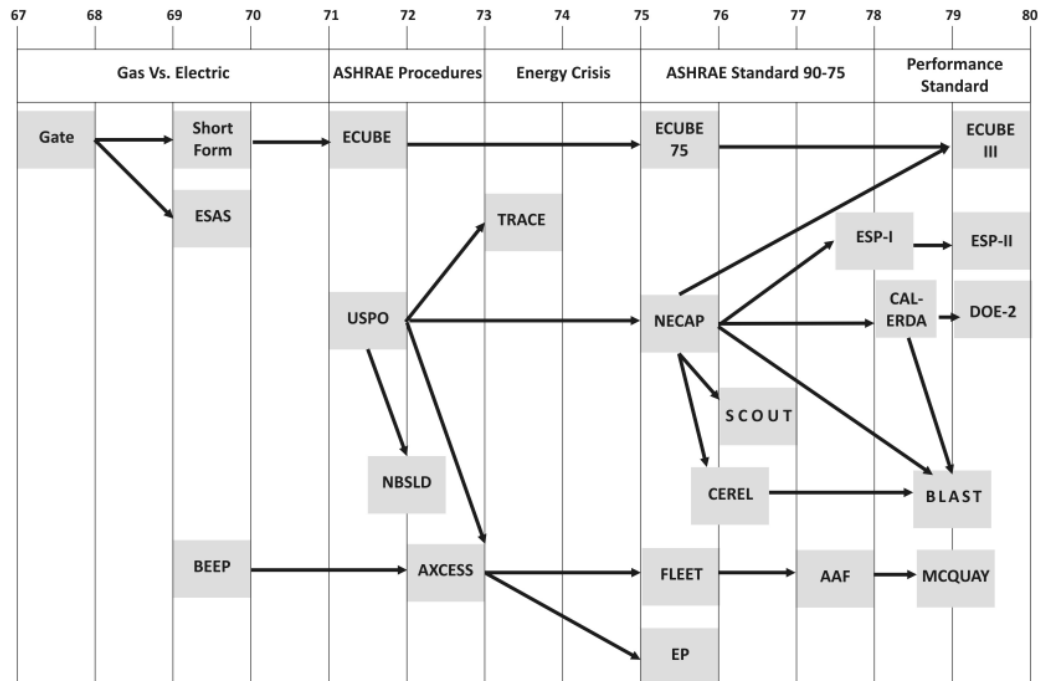


Figure 3.6: History of energy analysis computer programs  
Source: Judkoff et al. 2008 from Ferreira, F.

Table 3.4: Common programs used for building energy & environmental modelling  
Source: Crawley et al. 2008; 2005

Program	Developer
BLAST	University of Illinois at Urbana-Champaign
BSim	Danish Building Research Institute
DeST	Institute of Building Environment & Building Services, Tsinghua University, China.
DOE-2.1E	Lawrence Berkeley National Laboratory
ECOTECH	Square One Research/ AutoDesk
Ener-Win	Texas A & M University
Energy Express	CSIRO, Australia
Energy 10	National Renewable Energy Laboratory
EnergyPlus	Lawrence Berkeley National Laboratory
eQuest	Hirsch and the U.S. DOE
ESP-r	Energy Simulation Research Unit, University of Strathclyde
HAP	Carrier Corporation
HEED	UCLA Department of Architecture and Urban Design
IDA ICE	Swedish Institute of Applied Mathematics
IES <VE>	Integrated Environmental Solutions Ltd.
PowerDomus	Laboratorio de Sistemas Termicos (PUCPR)
SUNREL	Lawrence Berkeley National Laboratory
Tas	EDSL Ltd.
TRACE 700	Trane Company
TRNSYS	Solar Energy Laboratory, University of Wisconsin-Madison

### 3.3.4-Leading Organisations and Interest Groups

As the interest in the use of BEPP tools has grown, several industry groups and professional engineering organisations operating on the national and international scales have emerged. One of the primary goals of these organisations is the establishment of relevant interest groups and technical committees with the aim of facilitating appropriate training, encouraging continued education and the effective deployment of simulation (Hensen & Clarke 1999). The most important organisations in this field include:

- **The International Building Performance Simulation Association (IBPSA):** The association is a leading international organisation founded with the aim of promoting the science of building simulation (IBPSA 2010). Various regional affiliate organisations around the world have been set up, with two currently active in the UK (IBPSA-England and IBPSA-Scotland). IBPSA has a leading role in the promotion of continued education of practitioners through the organisation of international and regional conferences, educational seminars and the publication of the latest research and relevant information.
- **The UK Chartered Institute of Building Services Engineers (CIBSE):** CIBSE has been involved in the publication of various application manuals such as the Building Energy and Environmental Modelling Applications Manual AM11 that have become an industry standard. The institute is active in developing benchmarks and software testing procedures such as the CIBSE TM33:2006 'Test for Software Accreditation and Verification' (CIBSE 2006). In addition to running training and competency certification schemes, special interest CIBSE groups such as the Building Performance Group and the Building Simulation Group have been set up to inform and promote best practice in using computer-based BEPP tools for building related applications.
- **The American Society of Heating, Ventilating and Air-conditioning Engineers (ASHRAE):** The society is involved in the publication of several key documents including the ASHRAE Handbook of Fundamentals and ANSI/ASHRAE Standard 140 'Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs' (ANSI/ASHRAE 2007). The Building Energy Modelling Professional certification program (developed in collaboration with IBPSA-USA and the Illuminating Engineering Society of North America IESNA) has recently been introduced to certify competency in the use of BEPP tools (ASHRAE 2010).

### 3.4-The Application of Energy Performance Prediction Modelling Studies

The incorporation of building performance analysis into the design process utilises the full potential of computational methods in architecture (Schlueter & Thesseling 2009). The various stages of a modelling study from the development of the brief to the interpretation of results are identified in the CIBSE Guide AM 11 (CIBSE 1998).

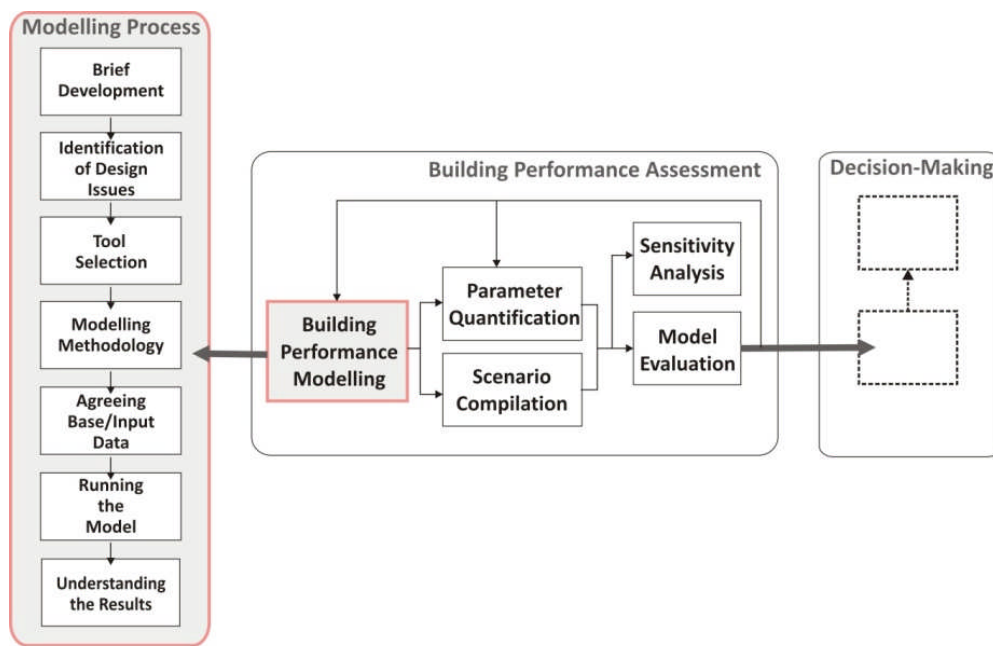


Figure 3.7: Process scheme of modelling as an input to building performance assessment and decision-making  
Source: Adapted from CIBSE 1998; De Wit 2004

The integration of this process into the procedure of building performance assessment is outlined in Figure 3.7. In the context of building energy performance, this process involves seven distinctive steps:

1. Brief development: The description of the modelling exercise, identification of purpose and required outputs.
2. Identification of the design issues: The collection of knowledge about the problem and the analysis of the potential influencing factors.
3. Tool selection: The evaluation and consequent selection of the (software) tools to implement the modelling study. Factors considered may include tool capability, robustness and accuracy.
4. Modelling methodology: The identification of the detailed steps of the modelling approach and its application to the study.
5. Agreeing input/base data: The collection of information and transformation of knowledge about the problem into viable inputs.
6. Running the model: Information and input is converted into a suitable model and the calculation/simulation exercise is performed.
7. Understanding the results: The modelling exercise generates 'raw' results data. In the analysis phase, this is first transformed into information, and then into problem-specific knowledge (Hensen 1994).

### 3.5-The Establishment of an Implementation Capability: Barriers and Issues in Application

As discussed, the trend throughout the world for modern building energy codes is moving towards a greater use of BEPP tools to support the assessment and verification of energy performance compliance (Marsh 2005; Hui 2002). The successful application of this approach mandates the establishment of a suitable 'implementation capability' to support its requirements (Figure 3.8). This process involves the consideration of various factors that lead to, firstly, the selection of the appropriate tools, and secondly the production of reliable results (Bartholomew et al. 1997).

Choosing the Right Program	<b>Modelling Methods</b>	<b>Can it analyse your problems?</b>	Producing Reliable Results	<b>Human resources</b>	What people with what skills are needed in a simulation team?
	<b>Program coding</b>	Do you need source code?			
	<b>Computer Specification</b>	Do you have the right machine?			
	<b>Input Interface</b>	How easy is the program to use?			
	<b>Output Interface</b>	Can results be understood?		<b>Databases &amp; support program</b>	Where does the input data come from?
	<b>Linked Modules</b>	Can CAD & other software help?			
	<b>Associated Databases</b>	Is necessary data available?			
	<b>User Support</b>	Can you get help easily?		<b>Training</b>	What, when and for whom?
	<b>User Base</b>	Are there other users who can be contacted?			
	<b>Validation</b>	How accurate is the program?		<b>Quality assurance</b>	How can you make sure a good job is done?
	<b>Cost</b>	What are the program/training costs?			

Figure 3.8: Establishing an implementation capability: Key factors  
Source: Bartholomew et al. 1997

Despite the growing interest in integrated energy performance prediction there are concerns about the actual role of computational assessment in the building design process (Hui 2003). Although contemporary programs are able to deliver an impressive array of performance assessments (e.g. Crawley et al. 2008; Hernandez et al. 2008; Xia et al. 2008; Hensen & Augenbroe 2004), it is suggested that the full potential of their use has yet to be fully realised (e.g. Hopfe et al. 2007; de Wilde 2004). Various factor associated with this phenomenon have been widely discussed in relevant literature (e.g. Judkoff & Neymark 2006; Karlsson et al. 2007; McElroy et al.2001). The main areas that have been highlighted as particular issues in the context of building performance assessment and compliance verification are discussed in detail as follows.

#### 3.5.1-The Uptake of Building Energy Performance Prediction Tools

A view that has been traditionally held is that while many computational performance prediction and analysis tools have been developed, their application and consequently their impact on the design process has been limited (Schlueter & Thesseling 2009). Even though studies have found evidence that suggests that in practice many more professionals use building performance prediction than is commonly realised, however in most cases this is still undertaken indirectly. Further analysis found that this was due to the fact that building designers in particular

have been reluctant to adopt what they perceive to be a difficult approach to apply (McElroy et al. 2001).

Although it is evident that the impact of design decisions is greatest in the earlier design phases, BEPP tools are mostly used by consultants working in the domain of building physics or HVAC systems design (de Wilde 2004) and are rarely used for supporting early design phase tasks such as feasibility studies and conceptual design evaluations (Hensen 2004). In an aim to rectify this, various devices have been put in place to support the transfer of building energy performance prediction into practice and to identify and eliminate barriers to the uptake of modelling (McElroy et al. 2001). In addition, research efforts have both aimed to upgrade existing tools and develop new tools that can be more easily and effectively used in the context of design development (Hensen 2004).

### **3.5.2-Predictive Accuracy and Results Variability in Building Energy Prediction**

The investigation of predictive variation in advanced BEPP tools has been the subject of various studies (e.g. Judkoff & Neymark 2006; Neymark & Judkoff 2002; Karlsson et al. 2007). These have explored both the extent of results variability between tools and the difference between the predicted and actual performance of buildings. Further studies investigating the causes of predictive variability have attributed this phenomenon to a number of factors that are listed below. Figure 3.9 illustrates relationship of a number of these factors in the variability of the results produced by BEPP tools.

- *The reliability and accuracy of physical input data:* Research has found that prescribed parameters such as occupancy can cause variations of up to 30% between estimates (Mason 2003). Input data that relies on user-based engineering judgment and experience can also cause variations of between 10-15% (Bartholomew et al. 1997). Issues regarding the accuracy of historic weather data and it's applicability to future scenarios have also been highlighted (Radhi 2009; Judkoff et al. 2008)
- *User skill in interpreting data and using the tools:* Tools cannot be treated in isolation from those actors who use the tools and/or from those who use the results (Lützkendorf & Lorenz 2006). User skill can play an important role in both in the accuracy of the input data and the variability of results (Bartholomew et al. 1997) where expert users have been known to capitalise on their knowledge of the modelling idiosyncrasies of certain tools to achieve more desirable outcomes (Papamichael 2000). Studies in this field have found that user influenced variability can affect results by up to approximately  $\pm 40\%$  on the average value (Guyon 1997).
- *Applicability of the tool:* To be truly applicable, a tool should be validated in terms of its capability to predict building performance for any type of building in any climate (Judkoff et al.



2008). However, tools are often only validated for a few test cases in specific climatic conditions. Where tools are not specifically applicable to a certain building type or climate, engineering judgement is often called upon to make decisions. This often involves the simplification of building geometry, material and systems specifications and the choice of alternative weather files. This process not only relies on approximations, but is also subject to the previously discussed user-influenced variability in determining the nature and extent of these approximations.

- **The calculation method:** Differences between the principles of calculating basic building physics and the accuracy (simplification/complexity) in accounting for parameters of various methods discussed in section (3.2.2) have been shown to be a primary factor in results variability (Rittelman & Ahmed 1985; Judkoff & Neymark 1995, 1995a). Simplifications associated with more simplified methods have in particular been shown to lead to incorrect results (Schlueter & Thesseling 2009).
- **Ability of the tool to predict real building performance when given perfect input data:** In reality, the way in which a building operates in practice is extremely complex. The modelling of this process to obtain accurate estimates is both difficult and prone to error (Mason 2003). Evidence from a study investigating a sample of 121 LEED-NC certified buildings in the USA (Turner & Frankel 2008) found that while the use of energy performance prediction was a relatively reliable predictor of average energy performance of the sample, measured energy use for over half the projects (individually) deviated by more than 25% from the generated design projections.

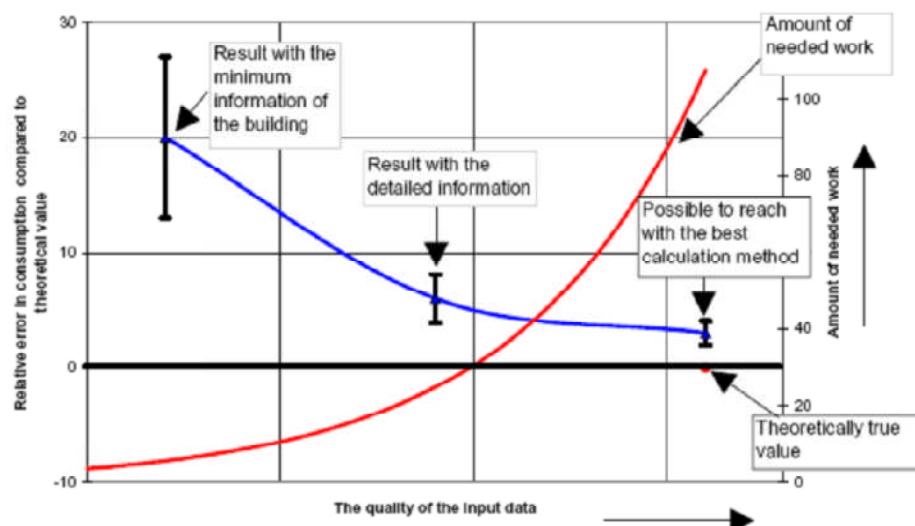


Figure 3.9: Relative importance of input values / different assumptions and calculation method  
Source: Kosonen & Shemeikka 1997

**Chapter Summary:**

- In the context of performance-based regulations, assessment refers to the process of identification and quantification of the performance objectives, the utilisation of objective and rigorous means of systematic assessment and verification of compliance using methods and tools that are available to the regulatory community.
- Assessment and verification methods and tools are a key component and a main challenge in applying performance-based energy regulations.
- While a variety of methods have been employed, given the increasing complexity of energy/ environmental systems, computer-based modelling is emerging as the most viable approach to design and performance assessment of unrealised buildings.
- The increasing international shift from prescriptive to performance-based regulations has been accompanied by a legislative call for the integration of building energy performance prediction in the design process.
- Computer-based BEPP tools have evolved over four generations, which can be correlated to increasingly realistic input data and the consequent ability of tools to more accurately predict building heat transfer mechanisms.
- The complex dynamic approach is generally considered to be more accurate (relative to other methods such as guidelines/ rules of thumb) in terms of its ability to create virtual models of more complex buildings and account for physical processes within them.
- This process allows the prediction and objective assessment of the overall energy performance of design proposals with the high degree of accuracy required by stringent energy policies.
- Various devices have been put in place to support the transfer of energy performance prediction tools into practice and to identify and eliminate barriers to its uptake.
- The investigation of predictive variation in advanced BEPP tools has been the subject of various studies, which have attributed this phenomenon to a number of factors.

## Chapter 4: The Regulation of Building Energy Performance in the UK

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*In accordance with the Directive on Energy Performance of Buildings (EPBD), a unified compliance methodology- the National Calculation Methodology (NCM)- for the energy performance of buildings was introduced in the UK Building and Approved Inspectors (Amendment) Regulations 2006 (England and Wales). The following presents a review of energy regulation affecting the UK built environment and examines the application of the NCM in the particular context of the new build non-domestic sector. The methodological framework, basic concepts and principles of process are defined and the properties and accreditation process of compliance verification tools are discussed. The various drivers and potential issues in the application of the NCM are highlighted.*

### 4.1-Introduction: Regulation of Building Energy Performance in the UK

The framework for the promotion of energy efficiency is defined by the central UK government (Schiellerup 2000). Within this system, the responsibilities for energy efficiency policies for the various economic sectors are dispersed among several actors (Kelly 2006). The responsibility for policy formulation and implementation was originally assigned to the Department of Environment Transport and the Regions (DETR) and the Department of Trade and Industry (DTI)<sup>8</sup>.

Over the years, these functions were re-allocated on several occasions to various departments including the Department for Business, Innovation & Skills (BIS)<sup>9</sup> and Department for Environment, Food and Rural Affairs (DEFRA) (Schiellerup 2000; Wagner & Haydock 2009). Support mechanisms to promote energy efficiency have also gone through a similar process of redistribution and re-allocation of responsibilities. This fragmented approach (Kelly 2006) has resulted in multiple bodies delivering a large number of similar programs (Ishwaran & Cimato 2007).

In an effort to eliminate these institutional overlaps and simplify procedures (Schiellerup 2000), the various responsibilities for energy policy (previously with BIS) and climate change mitigation policy (previously with DEFRA) were consolidated with the creation of the Department of Energy and Climate Change (DECC) in 2008 (Wagner & Haydock 2009).

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<sup>8</sup> Later rebranded as the Department for Business Enterprise and Regulatory Reform (BERR)

<sup>9</sup> A merger of the Department for Innovation, Universities and Skills (DIUS) and the Department for Business Enterprise and Regulatory Reform (BERR).

### 4.1.1-Implementation of Policies in the Built Environment: History of Building Control in the UK

Building control in the United Kingdom can historically be traced back to the early twelfth century with the issue of *'Fitz-Allwyn's Assize of Allaying Contentions to Assizes of Buildings'* in 1189 (Knowles & Pitt 1972). Developments in UK building control legislation (Listed in Table 4.1) illustrate a shift from anthropocentric social concerns such as public health and welfare that were addressed through the enforcement of prescriptive building regulations (Gann et al. 1998; Billington 2005), to increasingly eco-centric goals and performance oriented approaches from the mid 1970s onwards.

Table 4.1: Major developments in British building control legislation  
Source: Gann et al. 1998

Date	Regulation	Scope
1845	Public Health Act	First legislation covering structure, sanitation, fire,...etc in housing
1877	Model Bylaws	First minimum standard housing guidelines for local authorities
1952	Model Bylaws Series IV	Mandatory standards of performance and universal adoption
1965	Building Regulations	First comprehensive set of regulations for England & Wales
1976	Building Regulations	Simpler format & increased thermal insulation standards
1981	White Paper-Future of Building Control	First major shift from prescriptive to performance-based approach
1984	Building Act	New regulatory structure containing schedules and procedures
1985	Building Regulations	The introduction of Approved Documents
1991	Building Regulations	The inclusion of 13 supporting Approved Documents
2000	Building Regulations	Updated & consolidated amendments, reflected legislative changes
2006	Building Regulations	Transposition of EPBD, amendments to Part L compliance methods

### 4.1.2-Drivers for Energy Efficiency in the Built Environment

The seminal report advocating reform in the UK construction sector was the 1981 'White Paper on the Future of Building Control' (Gann et al. 1998). Further energy policy initiatives were based on the reform agenda proposed in the two key government documents; the Egan Report and the Latham Report (Egan 1998; Latham 1994) and the Energy White Paper of 2003 (DTI 2003).

Various programs that have been adopted on both the national and regional scale include measures that address emissions reduction targets in the built environment. An overview of both of these can be given as follows:

### 4.1.3-National Drivers: UK Policies and Targets

The UK is the eighth largest producer of CO<sub>2</sub> emissions in the world (GLA 2009) and the share per capita is approximately 1.5 times that of the global average (OECD/IEA 2009). On a national scale, the UK Government has taken a strong public stance on climate change and has made a number of commitments to reduce emissions (Saunderson et al. 2008). The following instruments that perform specific functions in the area of addressing climate change have been utilised:

- *Programs* provide the general policy framework for combating climate change. The Climate Change Program (2006) set out national action priorities with regard to emissions reductions.

- *Plans* detail the policies and measures to meet designated targets and include both the Energy Efficiency Action Plan (2007) and the more comprehensive Low Carbon Transition Plan (2009).
- *Acts* address the legislative aspects affecting various sectors and define the legally binding carbon budgets for each (Wagner & Haydock 2009). These include The Energy Act (2008) and the consequent Climate Change Act (2008).

As part of the strategy to move to a low carbon economy (Carbon Trust 2002) the commitments defined in the Climate Change Act 2008 have set out a policy that aims to reduce CO<sub>2</sub> emissions by 80% (relative to 1990 levels) by 2050, exceeding the required Kyoto agreement commitments (OPSI et al. 2008). The carbon budgets legislated by the UK in April 2009, which subsequently passed into legislation in May 2009, are based on a 34% cut with an annual average emissions reduction of 1.7% over the first three budget periods (CCC 2009).

#### **4.1.4-Regional Drivers: The Directive on Energy Performance of Buildings**

The European Climate Change Programme (ECCP) was launched in 2000 to identify and establish the necessary elements of a supranational (union-wide) strategy to implement the Kyoto Protocol (DEFRA 2006a). The ECCP has prioritised the effort to create synergies between the national policies of member states and EU goals with regard to energy efficiency (Janssen 2004). In the areas of environmental conservation and energy efficiency in particular, EU legislation has come to be considered a key factor in driving the national policy of member states (BRC 2003).

EU policy has identified the promotion of energy efficiency in buildings as a key objective of its energy and climate policy (CEC 2006; Ekins & Lees 2008). Consequently, the Directive on Energy Performance of Buildings (EPBD-Council Directive 2002/91/EC) was introduced in January 2003 with the overall objective to “promote the improvement of energy performance of buildings within the Community taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness” (Official Journal of the European Communities 2002, p.67).

Through its implementation framework, the EPBD has become a major catalyst throughout member states in the process of adopting performance-based energy standards for buildings that aim to remain proportionate to the current regulations of each country, while providing satisfactory design flexibility and avoiding unacceptable technical risks (King 2005). The EPBD has also aimed to be a key agent in the promotion of integrated energy performance prediction. Article 3 of the EPBD specifically requires that member states apply a ‘National Calculation Methodology’ (NCM) - a calculation approach for the demonstration of compliance with energy performance standards.

#### **4.1.5-Overview of the UK Built Environment: A Comparison of the Domestic and Non-Domestic Sectors**

The overall annual calculated emissions from the UK built environment in 2006 was estimated at just under 230 MtCO<sub>2</sub>, accounting for approximately 40% of the national total (CCC 2008a). The annual rate of increase of building energy consumption was recently estimated to be 0.5% (Pérez-Lombard et al. 2008). The updated energy projections issued by DECC (2010) show that, in total, the CO<sub>2</sub> emissions from building-related sectors will continue to be a major contributor to future emissions.

Future emissions growth in the built environment is influenced by such factors as underlying growth in the sector, changing demographics, the price of energy and energy efficiency legislation (Blundell 2000), the latter of which is considered to be the main driver towards increased energy efficiency for new construction (Clarke et al. 2008). Significant emissions savings in this sector can be obtained from with relatively modest reductions of about 6-27% in energy consumption (Kelly 2006), which can be achieved through energy efficiency improvement and the introduction of new technologies (CCC 2008a). Buildings have therefore come to be perceived as the locus of energy use with the highest cost-effective energy savings potential (Ekins & Lees 2008).

Both the Energy White Papers of 2003 (DTI 2003) and 2007 (DTI 2007) have recognised that policies to raise the energy efficiency of buildings have an important role in achieving emissions reductions targets and can make significant contributions to delivering a sustainable energy economy (Clarke et al. 2008). As a result, the built environment has in the past few years experienced a significant increase in activities concerning the formulation and promotion of energy efficiency policies (Saunderson et al. 2008).

The two typologies that make up the UK building stock are classified as the domestic and the non-domestic sectors, each of which are very distinct in character. In examining these differences, key information mainly concerning the building stock in England and Wales (the scope of this study) was compiled through a review of recent literature including academic studies this field and relevant Office of National Statistics (ONS) data. This information (summarised in Table 4.2) outlines the variation between sectors in terms of aspects such as specific energy use and resultant emissions patterns.

While the domestic sector constitutes the majority of energy use and resultant emissions in the built environment, various studies such as the first CCC report 'Building a Low-Carbon Economy - The UK's Contribution to Tackling Climate Change' have also recognised the significant potential for emissions reductions in the non-domestic sector (CCC 2008a). The construction of new non-domestic buildings designed to more energy efficient standards can in particular act as exemplars for the encouragement of the uptake of energy efficiency measures and provide an

opportunity for exploring a wide scope of energy efficient technologies. There is also evidence that in the long term, that the construction of new services buildings designed to consume a small fraction of the energy required by their older equivalents (per m<sup>2</sup> of floor area or per occupant) provides one of the greatest scopes for achieving advances in saving energy in the built environment (Blundell 2000).

Table 4.2: Main characteristics of the domestic and non-domestic sectors

	Domestic	Non-Domestic
<b>Characteristics</b>	<ul style="list-style-type: none"> <li>Largely homogeneous, showing comparatively little diversity in function, form and ownership.</li> </ul>	<ul style="list-style-type: none"> <li>Largely heterogeneous, showing great diversity in function, form &amp; ownership (Steadman et al. 2000; Bruhns 2008; Hinnels 2008)</li> </ul>
<b>Number of properties</b>	<ul style="list-style-type: none"> <li>Both the Office of National Statistics Census information (ONS 2008) &amp; Valuation Office (DCLG 2009a) list hold information on approximately 24,500,000 domestic properties in England &amp; Wales.</li> </ul>	<ul style="list-style-type: none"> <li>Exact number is difficult to estimate (Steadman et al. 2000) due to the absence of reliable data (Bell 2004). The Valuation Office rating list estimates that there are around 1,828,000 non-domestic properties in England and Wales (VOA 2010)</li> </ul>
<b>Construction/ replacement rate<sup>1</sup></b>	<ul style="list-style-type: none"> <li>Construction rate: 2009/2010<sup>2</sup> = 0.48 % (DCLG 2010b) Typical ~ 0.65 %<sup>2</sup> (DCLG 2010b; DEFRA 2004)</li> <li>Replacement rate: 2009/2010 = 0.66% (Jowsey &amp; Grant 2009) Typical ~ &lt; 1% (RIBA 2009)</li> <li>Annual construction activity (m<sup>2</sup>)= 18,252,000 (Dyrbol et al. 2009)</li> <li>Nearly 40% built before 1930s (Heritage Link 2007). It is therefore estimated that 70% of the stock that will be inhabited in 2050 already exists (SDC 2006).</li> </ul>	<ul style="list-style-type: none"> <li>Construction rate: 2009/2010<sup>2</sup> = 1.86% (VOA 2010; DCLG 2009c) Typical ~ 1-2% (Ravetz 2008)</li> <li>Replacement rate: 2009/2010 ~ 1-2% (GLA 2009; APUDG 2008) Typical ~ 1-1.5% (Steemers 2003)</li> <li>Annual construction activity (m<sup>2</sup>)= 18,000,000 (Dyrbol et al. 2009)</li> <li>Comparatively less old than the domestic sector. 77% of the current stock was built prior to the introduction of conservation of fuel &amp; power measures in 1985 Building Regulations. By 2050, between 30-50 % of current stock will be replaced (Cassar et. al 2007; UKGBC 2007).</li> </ul>
<b>Energy / Emissions patterns</b>	<ul style="list-style-type: none"> <li>Estimated to be at 149 MtCO<sub>2</sub> (CCC 2008a)</li> <li>Accounts for around two thirds of building related emissions over 27% of the overall UK total (Bordass et al. 2004).</li> <li>Over recent decades, total energy demand has remained broadly stable; emissions have fallen slightly, mainly due to decarbonisation of grid electricity (Reeves 2009).</li> </ul>	<ul style="list-style-type: none"> <li>Estimated to be 78 MtCO<sub>2</sub> (CCC 2008a).</li> <li>Accounts for around one third of building related emissions &amp; over 15% of the overall UK total (Bordass et al. 2004).</li> <li>Office and retail buildings are the most energy intensive typologies typically accounting for over 50% of the total sectoral energy consumption (Pérez-Lombard et al. 2008).</li> </ul>
<b>Contributing factors</b>	<ul style="list-style-type: none"> <li>Main contributor is the use of fossil fuels to provide energy required for space heating &amp; hot water (EST 2008).</li> </ul>	<ul style="list-style-type: none"> <li>75% of energy consumption can be attributed to heating and lighting uses. Emissions dominated by lighting and cooling (Bruhns et al. 2006).</li> </ul>
<b>Target/ Potential for reductions</b>	<ul style="list-style-type: none"> <li>A reduction of 29% (below 2008 levels) by 2020 is set out in the Low Carbon Transition Plan (DECC 2009).</li> </ul>	<ul style="list-style-type: none"> <li>In the period to 2020 emissions for the non-domestic sector are forecast to fall by 28% underpinned by reductions in energy demand (CCC 2009) &amp; the lower carbon intensity of electricity (CCC 2008a).</li> </ul>

<sup>1</sup>Figures are based on latest available statistics, which record the period during the economic downturn and slowdown in construction activity. An example of typical figures is provided (where available) for comparison.

<sup>2</sup>Calculated values. Sources of information on which calculations were based are cited.

## **4.2-Framework of Building Regulations**

Regulatory interventions in the UK have two main sources: the UK Government, which implements its policy objectives through domestic policy decisions and EU legislation in the form of regulations and directives. With regard to energy efficiency in the built environment, two aspects must be considered; the general framework of energy efficiency policies and the more specific context of the implementation mechanism involving the building control system and building regulations.

On the domestic level, legislation implementation is based on a devolved administration structure subdivided into three jurisdictions (England and Wales, Scotland and Northern Ireland) each governed by a separate body and regulation documents (BRC 2003). The following will mainly discuss the case of England and Wales (the scope of the study), however the legislative systems in all three jurisdictions are interrelated, with many commonalities (Liu 2007) and all ultimately contribute to achieving the overall UK targets.

Within this framework the building legislation control system in England and Wales, originally governed by The Office of the Deputy Prime Minister (ODPM), was reassigned to the Department of Communities and Local Government (DCLG) in May 2006. The legislative structure is based on a system of primary and secondary legislation supported by non-mandatory technical guidance (Billington 2005), the elements of which can be described as follows:

### **4.2.1-Building Acts**

As the primary source of legislation in England and Wales, the 1984 Building Act is a United Kingdom statute that contains the 'enabling powers' for the Secretary of State to make regulations with respect to the design, construction and demolition of buildings, and the provision of associated services, fittings and equipment (ODPM (Later DCLG) 2006a). Similar legislation that applies across Scotland is set out in the Building (Scotland) Act 2003 (Scottish Government 2003).

The powers contained in the 1984 Building Act have in recent years been amended through the introduction of further acts such as the Sustainable and Secure Buildings Act 2004 and the Climate Change and Sustainable Energy Act 2006. These have extended the scope of legislation to include issues of sustainable development, environmental protection, reduction of GHG emissions and the use of renewable energy technologies (Clowes 2006).

### **4.2.2-Building Regulations**

The first regulatory instrument created under the Building Act 1984 was the Building Regulations 1985. Subsequent regulations have been introduced and the current regulations are the Building Regulations 2000 (ODPM (Later DCLG) 2006a). As the secondary source of legislation, these define building projects subject to control, notification procedures and



requirements (stated in terms of performance standards) with which aspects of building design and construction must comply (ODPM (Later DCLG) 2006b; Stellakis & Lupton 2003). Any amendments to the current version of the Building Regulations are introduced into legislation through Statutory Instruments referred to as Building (Amendment) Regulations or Building and Approved Inspectors (Amendment) Regulations.

#### 4.2.3-Approved Documents

These are non-mandatory 'second-tier' guidance documents that contain practical (quantified) technical solutions on how regulations can be met. For England and Wales, there are currently 14 Approved Documents (A to L), these comprehensively cover such aspects as structure, fire safety and energy efficiency and fuel conservation standards. Corresponding technical guidance documents exist in both Scotland and Northern Ireland. As well as providing some clear prescriptive approaches that can be followed, these documents describe alternative performance-based solution routes to the demonstration of compliance with the requirements of the Building Regulations (DCLG 2006c).

#### 4.3-The Implementation of the EPBD Directive in England and Wales

As part of its commitments to the EU, the UK has sought to further develop its energy efficiency program for the built environment and bring related energy policies up to par by transposing EU requirements into law. The UK is considered to be one of the more advanced member states in terms of the implementation of the requirements of the EPBD (Balaras et al 2005), which is supported by the Directive Implementation Advisory Group (DIAG). The EPBD has sought to standardise and strengthen building energy-efficiency requirements (Levine et al. 2007) through the introduction of four major actions (Bughair 2006):

- The introduction of **methodologies**, which are agreed measurements of relative building energy performance specific to the regulatory requirements of each member state.
- Mandating of regular **inspections** and re-evaluations of building systems.
- The issue of **energy certificates** to record energy performance.
- The introduction of improved **minimum standards** for new buildings.

With regard to the case of England and Wales, following Regulation 17A of Building Regulations 2000 (Office of Public Sector Information 2000), the requirements of the EPBD and the commitments of the Energy White Paper of 2003 were transposed into legislation through the introduction of the new Building and Approved Inspectors (Amendment) Regulations 2006 (England and Wales). The final version of these regulations and the associated technical guidance-Approved Document Part L 2006 (Conservation of Energy and Power) -came into force in April 2006 (DCLG 2006b).

### 4.3.1-Amendments to Approved Document Part L

Approved Document Part L is the relevant second-tier guidance document affecting energy efficiency in buildings. The corresponding documents in Scotland and Northern Ireland are Section 6 and Part F, respectively. A key decision during the development of the 2006 Amendment Regulations was to incorporate several changes to Part L, which if fully realised, were expected to further the regulatory contribution towards achieving the national CO<sub>2</sub> emissions reduction targets by an estimated 1 MtCO<sub>2</sub>/year by 2010 (ODPM (Later DCLG) 2004).

Since the previous version of the Approved Documents Part L (2002) already incorporated some elements relating to the requirements stated in the various articles of the EPBD, in transposing the requirements of the EPBD for the non-domestic sector into national legislation, the following amendments were introduced in Approved Document Part L2A 2006 (Table 4.3).

Table 4.3: Main amendments to Approved Document Part L2A 2006

EPBD Article	Action/Amendment to Approved Document Part L2A
<b>Article 3: Adoption of a methodology</b>	The replacement of the various alternatives for compliance demonstration (elemental methods, target U-value & carbon index for domestic & the elemental, whole building & carbon emission calculations methods for non-domestic buildings) outlined in the 2002 Regulations, with a single National Calculation Methodology (NCM) for each sector.
<b>Article 5: New Building</b>	The inclusion of renewable energy measures such as active solar systems & other heating & electricity systems based on renewable energy sources.
<b>Article 7: Energy performance certificate</b>	The introduction of Energy Performance Certificates (EPC) -the 'Asset Rating'-when a building is constructed, sold or rented & Display Energy Certificates (DEC) - the 'Operational Rating'- to measure in-use performance of the building based on actual (observed) metered energy consumption.

### 4.3.2-Criteria for Compliance

Five criteria for compliance are defined in Approved Document Part L2A (DCLG 2006b). The requirements of these criteria can be defined as follows:

- **Criterion 1- Achieving an acceptable building CO<sub>2</sub> emission rate:** The 'as-designed' Building Emission Rate (BER) should be calculated using the approved methodology and be no greater than a defined target level.
- **Criterion 2-Limits on design flexibility:** Performance of building fabric (envelope) and fixed building services should be no worse than defined limits.
- **Criterion 3- Limiting the effects of solar gains in summer:** For occupied spaces, a calculation should be performed to demonstrate that adequate measures have been undertaken for the minimisation of overheating.
- **Criterion 4- Quality of construction and commissioning:** The 'as-built' calculation of the BER should be consistent with the predicted 'as-designed' BER. This final calculation should reflect any changes made during construction and include the achieved air permeability, ductwork leakage and commissioned fan performance.

- **Criterion 5- Provision of information:** The building owner should be provided with sufficient information about the building, the fixed services and their maintenance requirements. This information can be provided in the form of a building logbook.

### 4.3.3-The Definition of the National Calculation Methodology

In accordance with the requirements stated in Article 3 of the EPBD, the National Calculation Methodology (NCM) was defined by the ODPM (ODPM (Later DCLG) 2003) as the unified calculation-based methodology for the demonstration of compliance with Criterion 1 of Approved Document Part L2A. The associated calculation tools used for its application were first approved in Annex I of the ODPM Circular 03/2006 (ODPM (Later DCLG) 2006b). The specific procedures for implementation were described in the guide 'The National Calculation Methodology for Determining the Energy Performance of Buildings' (2006a), with further amendments published in various editions of the 'Notice of Approval' superseding Circular 03/2006.

The NCM marks a significant change in that it adopts a holistic approach to determining compliance that utilises calculation tools to quantify energy performance in terms of CO<sub>2</sub> emissions indicator rather than in terms of energy consumption or demand (SBSA 2006). Its implementation aims not only to standardise compliance verification, but in theory also promotes the standardised use of BEPP tools from the earliest design stages.

Although the NCM is defined as the single compliance methodology, Approved Document Part L is subdivided into four separate documents that distinguish between various building types (domestic and non-domestic buildings) and between new or existing buildings, defining a separate approach to implementing the methodology for each (Table 4.4).

Table 4.4: Application of the NCM to building typologies

Building Typology	Relevant Approved Document	Compliance Implementation
New Dwellings	ADL1A	The Standard Assessment Procedure (SAP2005)
Existing Dwellings	ADL1B	A variant of SAP2005 that requires reduced data input.
New Buildings other than Dwellings	ADL2A	Simplified Building Energy Model (SBEM) or accredited commercial tools
Existing Buildings other than Dwellings	ADL2B	SBEM 'inferencing engine' with default data for existing building elements

### 4.4-The Compliance Procedure for the Non-Domestic Sector

The application of the National Calculation Methodology in the context of the new non-domestic sector replaces the three alternative routes previously offered in the 2002 Regulations as the sole compliance method for the compliance criteria set out in the relevant second tier guidance - Approved Document Part L2A (ADL2A).

Criterion 1 in Part L2A requires that the proposed building achieves what is defined as “an acceptable building CO<sub>2</sub> emission rate” (DCLG 2006, p.14) compared to a relative target emission benchmark. The associated methodology (Figure 4.1) for demonstrating compliance with this requirement entails the use of accredited tools (AECOM/DCLG 2010) to model the actual building (ACT) and quantify its energy performance expressed as CO<sub>2</sub> emissions in accordance with the process described in Box 4.1.

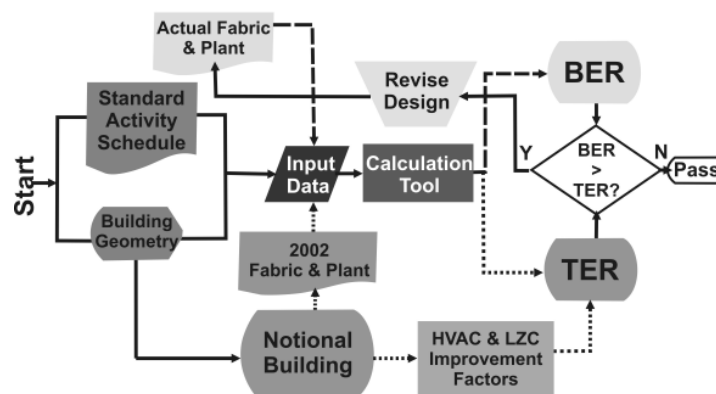


Figure 4.1: Schematic representation the application of the NCM process for the non-domestic sector  
Source: Cartmell 2006; Jaggs 2007

**Box 4.1: The non-domestic compliance process**

- 1- **Model the actual building (ACT) and generate Building Emissions Rate (BER)**
- 2- **Generate the equivalent Notional building (NOT)**
- 3- **Generate Target Emissions Rate (TER) according to the compliance equation (1) where:**  

$$TER = C_{NOT} \times (1 - \text{improvement factor}) \times (1 - \text{LZC benchmark}) \dots \dots \dots (1)$$
- 4- **Compare BER & TER to determine compliance where:**  
 If Building Emission Rate (BER) ≤ Target Emission Rate (TER) → Pass (Compliance)  
 If Building Emission Rate (BER) > Target Emission Rate (TER) → Fail (Non-Compliance)

The Notional (NOT) building is a building of equivalent size, shape and usage to the proposed design (Figure 4.2) that uses standards set by the ‘Elemental Method’ of the 2002 edition of the regulations (DTLR 2002). The calculated annual CO<sub>2</sub> emissions level of the Notional building is referred to as  $C_{NOT}$  (kg/m<sup>2</sup>/year).

The main benchmarks that are compared to determine compliance are defined as:

- The Building Emissions Rate (BER): This is the mass of CO<sub>2</sub>, emitted per year per square meter of the total useful floor area of the proposed building (kg/m<sup>2</sup>/year).
- The Target Emissions Rate (TER): This is defined as “the minimum energy performance requirement specified in Regulation 17B. It is the mass of CO<sub>2</sub>, emitted per year per square meter of the total useful floor area of the building (kg/m<sup>2</sup>/year)” (DCLG 2006b, p.13).

The TER is calculated by applying an improvement factor determined according to the HVAC strategy employed (this ranges between 15-20%) in addition to a universal Low Zero Carbon benchmark factor of 10% to the notional building. Accordingly, the overall reduction of the TER over the  $C_{NOT}$  ranges between 23.5%-28%.

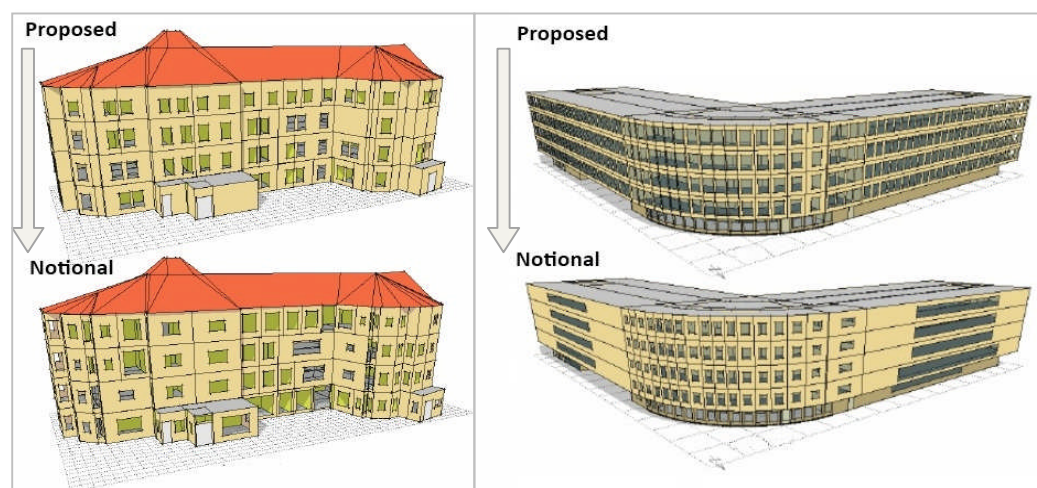


Figure 4.2: An example of proposed designs and their notional equivalents generated by an accredited compliance tool  
Source: Marsh 2005

Even though flexibility for the designer in choosing how to achieve the required reduction target is maintained, some limits ('back-stop values') on particular elements are imposed to protect against over reliance on any one element to meet them (e.g. the use of an excessive number of solar panels on a poorly insulated building) (Tebbitt 2006).

#### 4.4.1-Overview of Accredited Compliance Demonstration Tools

According to the requirements of the EPBD, the tools used to carry out the energy compliance calculations for non-domestic buildings (BRE 2005) must be able to perform the following calculation (and analytical) procedures (Carey 2006a; Floyd 2006; Anderson 2006):

- The calculation of energy use and resultant CO<sub>2</sub> emissions of a building.
- The comparison of benchmarks to demonstrate compliance with criteria set out in Approved Document L2A.
- The creation of an 'Asset Rating' for new and existing buildings.

As the basis of the governmental strategy for the implementation of the NCM, key criteria were outlined to ensure the suitability of the default calculation tool for the purposes defined (Hitchin 2005; Dijk 2007). Table 4.5 presents an example of the evaluation of the various calculation methodologies considered for the implementation of the EPBD (Hitchin 2005). Although this work was undertaken for an EU member state (the Czech Republic), it was primarily based on a similar evaluation that was undertaken for the UK (Hitchin 2003).

Table 4.5: The evaluation of calculation methodologies for the implementation of the EPBD  
Source: Hitchin 2005

Method	Simplified methods			Simulation methods		
Criterion	Simple degree-day	Developed degree-day	Monthly heat balance	Simplified dynamic	Prescribed simulation tool	Competing simulation tools
Availability as Certification tool	****	***	*****	****	***	**
Repeatability	*****	*****	*****	*****	****	**
Affordability	*****	****	****	****	**	**
Technical scope and applicability	*	***	***	****	*****	*****
Technical soundness	*	***	***	****	*****	*****
Adaptability & stability	*	**	***	****	*****	*****
Transparency	*****	****	****	****	***	*
Consistency with other countries	**	***	*****	*	*	*
Weather data availability	*****	***	***	*	*	*
Evaluation Scale	***** Highest - * Lowest					

For the case of the UK, the evaluation of these methodologies resulted in the implementation of a strategy that involved the use of a combination of two of the defined approaches:

- The development of a free standardised default tool: The Building Research Establishment (BRE) was commissioned to develop a suitable 'default' tool based on the monthly heat balance method. The first official version of the tool-the quasi steady-state Simple Building Energy Model (SBEM v.1.0 and its interface iSBEM) was consequently released in December 2005 (Carey 2006a; Davidson 2005).
- The implementation of a mechanism to allow for the development of competing commercial simulation software: This approach employed procedures to encourage market competitiveness in the development of more technologically capable software, required to meet the modelling requirements associated with the functional complexities and volumetric variability of the largely heterogeneous non-domestic stock (e.g. Wright 2005; Bruhns 2008; Pérez-Lombard et al. 2008).

As a result of this strategy, three tool classes are currently available. Figure 4.3 illustrates the relationship between the three tool classes and a review of their main features is summarised in Table 4.6, this is followed by a more detailed discussion of each.

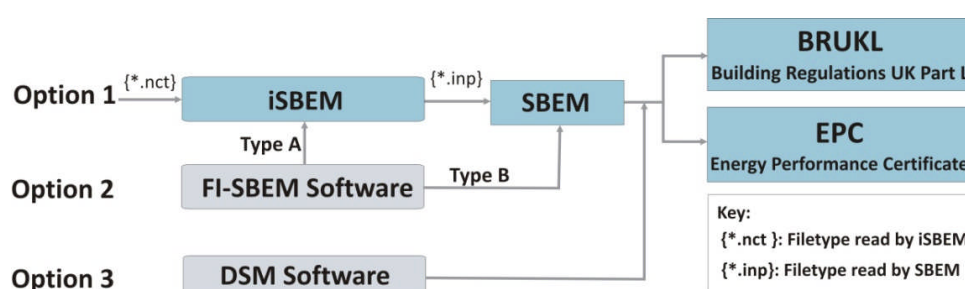


Figure 4.3: Relationship between tool options  
 Source: AECOM/DCLG 2010

Table 4.6: Main features of tool options

Option	Input Method/Data	Calculation Methodology	Outputs
<b>SBEM</b>	Non-graphical, Microsoft Access based input forms. Data includes geometry, thermal characteristics of constructions, HVAC properties & renewable energy systems. Contains some default values such as HVAC efficiencies.	Quasi steady-state monthly average calculation based on the Dutch methodology NEN 2916:1998 (Energy Performance of Non-Residential Buildings).	-BRUKL/SBEM outputs -Data reflection reports -EPC Certificates
<b>FI-SBEM</b>	A front-end graphical interface is used only for building geometry input, and then interfaces with iSBEM where additional data is entered.	Both types interface with SBEM calculation engine, relying on the same algorithms to implement a quasi steady-state monthly average calculation method.	-BRUKL/SBEM outputs -Data reflection reports -EPC Certificates
<b>TYPE A</b>	A front-end graphical interface is used for building geometry and information input. Data generally conforms to iSBEM standard; degree of detail varies due to individual tool capabilities.		
<b>TYPE B</b>			
<b>DSM</b>	3D CAD front-end modules allow building geometry to be input &/or imported from CAD packages, 3D BIM & other software. Includes more detailed input options /extensive databases for materials & systems.	Dynamic detailed hourly calculation method using each tools own algorithms.	-BRUKL/SBEM outputs -Data reflection reports -EPC Certificates -Load calculations, energy performance analysis results

The main output documents relevant to Part L2A compliance that are produced by all accredited tools are illustrated in Figure 4.4, these include:

- The Building Regulations UK compliance document (BRUKL) which lists the outcome of calculation with regard to the various criteria.
- The SBEM outputs document which includes information such as annual energy consumption in graphical form

In addition two further documents are generated:

- Data reflection reports which include a comprehensive list of the input values that are used/assumed.
- All tools also produce Energy Performance Certificates (EPCs) which describe the building Asset Rating.

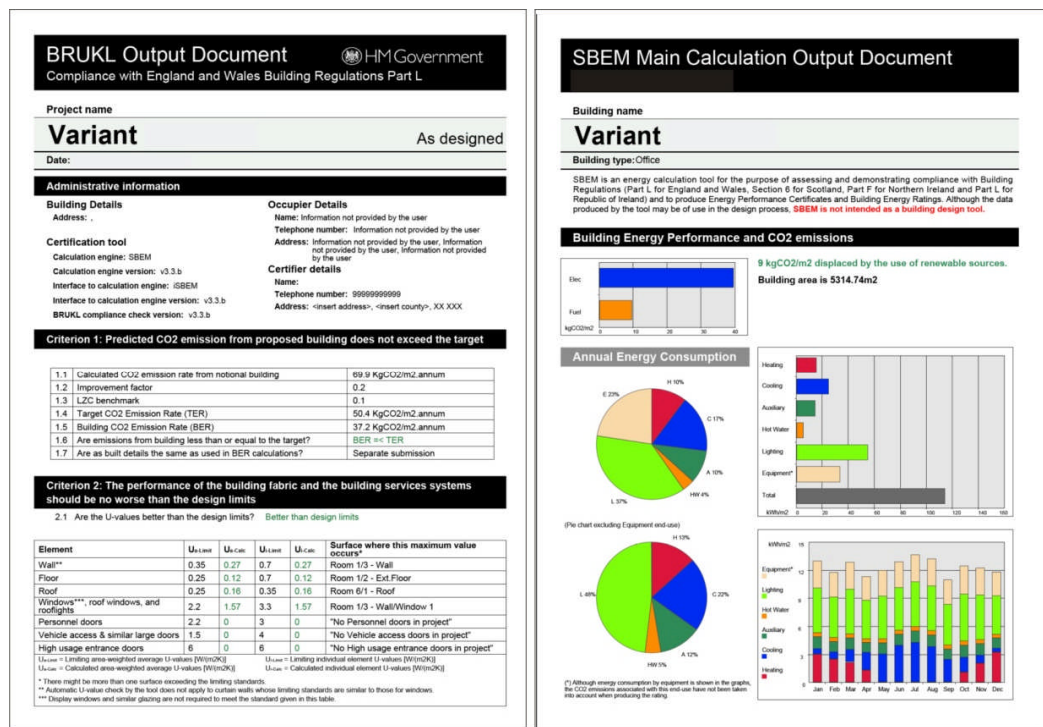


Figure 4.4: The BRUKL and SBEM main calculation output document

#### 4.4.1.1-The Default Calculation Tool: The Simple Building Energy Model

SBEM is a C++ language-based tool, its calculation procedures are largely based on the European CEN standard prEN ISO 13790. Much of the basis for prEN ISO 13790 was provided by the Dutch standard NEN 2916:1998 (Energy Performance of Non Residential Buildings), a simplified calculation method based on a monthly heat balance approach that had been in use for many years by Dutch building control.

Since the NEN 2916:1998 methodology used an energy balance method for calculating the energy performance that factored in all of the energy consuming services in a building, it was considered reasonably well suited to the requirements of the EPBD. The methodology was then modified to comply with the CEN standards developed to support the implementation of the Directive (Kennett 2006; Martinez Davison et al. 2006; Elrick 2006; Doyle 2008; Lillicrap & Davidson 2005).

Although prEN ISO 13790 allows for different levels of complexity in calculation (simplified hourly, simplified monthly and detailed calculations) (Roulet & Anderson 2006), the simplified monthly calculation method was selected for SBEM because it was deemed sufficient for the requirements and suitable for the timescale of implementation. In areas where these standards were incomplete, new methods based on the same principles were developed (Hitchin 2006). During the consultation process for amending Part L2A, the technical limitations of the monthly calculation approach (with regard to the analysis of night cooling and the assessment of overheating risk) were highlighted (Elrick 2006).



The SBEM tool includes the following components (Carey 2006a; Davidson 2005):

- The SBEM calculation core containing a compliance checking module.
- iSBEM, a Microsoft Access-based user non-graphical interface for the purposes of building data input. Data requirements include geometry, thermal characteristics of constructions, HVAC properties, and renewable energy systems. The interface contains some default values such as HVAC efficiencies.
- A set of databases that describe building activities, fabric, services and weather data from which the tool can draw information.

#### **4.4.1.2-SBEM Front-End Interfaces (FI-SBEMs)**

FI-SBEM software provides a front-end graphical interface for input to the SBEM calculation engine. The tools rely on the same algorithms and therefore implement the same quasi steady-state calculation method. The two sub-types defined within this category are:

- Type A: The interface is used only for building geometry input, and then interfaces with the graphical interface (iSBEM) where additional (systems) data can be entered.
- Type B: The front-end graphical interface is used for building geometry and information input. The data generally conforms to the iSBEM standard requirements and the degree of detail used for specification varies according to individual tool capabilities.

#### **4.4.1.3-Dynamic Simulation Modelling Tools (DSMs)**

Dynamic Simulation Modelling (DSM) software is a conventional reference that is applied to sophisticated building analysis tools that implement complex dynamic methods to model the dynamic response of buildings (AECOM/DCLG 2010; Lim 2009; DCLG 2008c). In the context of the NCM, the accredited DSMs generally perform detailed hourly calculations utilising each tools own proprietary engine and calculation algorithms.

DSMs often make use of 3D CAD front-end modules to allow building geometry to be input or imported from CAD packages, 3D BIM tools and other software. Input requirements are more detailed and access extensive materials and systems databases. In addition to the previously defined compliance documents, these tools are also used for the analysis and production of load calculations and more detailed energy performance results.

In addition to these compliance demonstration tool options, Operational Rating Calculation (ORCalc) software that is used to calculate the operational rating of a building, produce Display Energy Certificates (DECs) and issue advisory reports is also available.

#### 4.4.2-Tool Validation and Accreditation Schemes

In the software development cycle, testing is an essential activity that involves “observing the execution of a software system to validate whether it behaves as intended and identify potential malfunctions” (Bertolino 2007, p.1.). With the exception of SBEM, the accreditation of all tools is subject to the requirements of the Building Energy Calculation Software Approval Scheme UK (BECSAS) (Lim 2009).

This scheme was established as an extension of DCLG activities to facilitate software approval (AECOM/DCLG 2010). The specified accreditation procedure involves a series of prescribed validation tests that assess the suitability of each tool for the purposes of implementing the NCM (Figure 4.5). Since the introduction of the regulations and initiation of the scheme, the accreditation procedures have changed to reflect developments in software. The three validation routes currently used are specified as (AECOM/DCLG 2010):

- Full validation: For new software not previously approved by DCLG under BECSAS the process involves two stages. Stage one is a self-assessment procedure undertaken by the software developer using designated test cases, and in the case of DSMs, additional testing procedures. The results are submitted for validation and discussed via a two-way consultation to resolve any non-compliance issues. Upon satisfactory completion of stage one, a second stage live-assessment attended by the software developer and the scheme assessors is undertaken. Here, the software must further demonstrate compliance and adequateness for the required function in the production of relevant calculations and documents.
- Re-validation: For software previously approved by DCLG under BECSAS, re-validation may be triggered by major changes in guidelines and specification, by special instruction from DCLG or by request of BECSAS based on specified circumstances during an evaluation of the software. This process also involves the two-stage approach used in full validation; however, the self-assessment stage does not include a consultation process.
- Self-validation: For software previously approved by DCLG under BECSAS, self-validation is voluntarily undertaken by the developer in the case of version upgrade or update. This process only requires the first self-assessment stage to be completed.

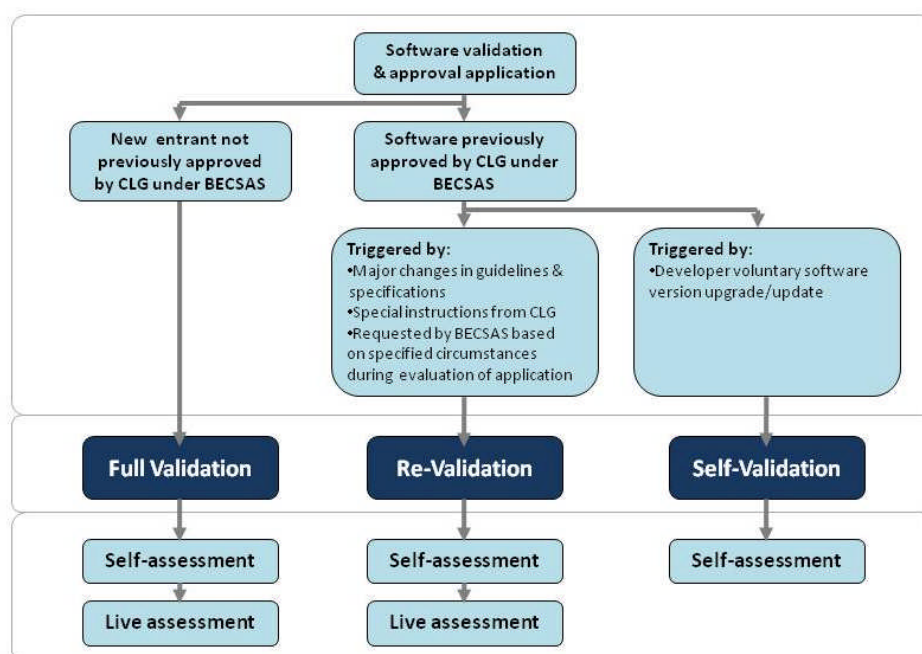


Figure 4.5: Non-domestic software approval process flow

Source: AECOM/DCLG 2010

Ideally, a preliminary self-assessment is carried out to verify software compatibility with test specifications and requirements. The designated test cases for each of the tool classes can be described as follows:

- For FI-SBEMs: Testing involves the use of a set of two separate test models, the outputs of which must be in exact agreement with DCLG reference outputs.
- For DSMs: Testing is segregated into two stages. The software is first tested according to procedures defined in the technical document TM33:2006 'Test for Software Accreditation and Verification' (CIBSE 2006). These procedures have been revised to incorporate issues related to the NCM modelling guide (DCLG 2008c; Lim 2009) and are intended to assess calculation algorithms to ensure that they are technically robust. Here, generated results should be within the stated stringent error margins of reference outputs. Following this, further validation tests involve a set of 10 'Enhanced Test Models' to confirm that the modelling of the notional and reference buildings complies with the requirements of the NCM modelling guide and assess the modelling of renewable energy sources.

With new tools being continually developed and accredited, the range of accredited BEPP tools is constantly expanding. Table 4.7 lists the main features associated with each of the accredited tools available at the time of writing (June 2010).

Table 4.7: BEPP tools accredited for Part L2A compliance calculations-Updated June 2010

Tool	Version	Developer	Website*	Calculation Engine	Description*	Applicability*
<b>Default Tool</b>						
<b>SBEM (iSBEM)</b>	V3.5.a	BRE/ DCLG	<a href="http://www.ncm.bre.co.uk">http://www.ncm.bre.co.uk</a>	SBEM V3.5.a	Default calculation tool that uses a non-graphical Microsoft access-based input intensive format.	Limited applicability only suitable for basic building forms. Allows use of alternative interfaces.
<b>FI-SBEM Tools</b>						
<b>Carbon Checker</b>	V1.5	Southfacing	<a href="http://www.builddesk.co.uk">www.builddesk.co.uk</a>	SBEM V3.5.a.0	An interface to SBEM that uses a minimised, simple step-by-step wizard for entering building properties & a 2D/3D interface for entering building geometry.	More suitable for basic building forms. Import facility available for CAD packages
<b>CYMAP</b>	V2010	CYMAP	<a href="http://www.cymap.com">www.cymap.com</a>	SBEM V3.4.a (via iSBEM)	An interface incorporated into a building services program. Data transferred to iSBEM limited to geometry, orientation, fabric & HVAC nametags. Remaining input entered in iSBEM.	Interfaces to the iSBEM interface rather than the SBEM calculation engine. SBEM limitations apply.
<b>Design- Builder SBEM</b>	V 2.2	Design-Builder Software Ltd	<a href="http://www.designbuilder.co.uk">www.designbuilder.co.uk</a>	SBEM V3.5.a.0/ EnergyPlus	An interface to SBEM with simple 2D tracing based input. Has multi-level 3D Open Gl & multi engine modelling capability	Suitable for most building types. Limitations in modelling some HVAC strategies.
<b>Design Database</b>	V 25.02	Bentley Systems (UK) Ltd	<a href="http://www.bentley.com/en-GB">www.bentley.com/en-GB</a>	SBEM V3.5.a.0/ EnergyPlus	An interface that allows access to all features of Hevacomp package, including links to EnergyPlus. Input is based on simple 2D tracing accessing construction databases to create 3D models.	The interface is limited by SBEM engine capabilities
<b>Graphical-iSBEM (G-iSBEM) +Sitenotes</b>	V16.0	Masterpiece-Systems Ltd	<a href="http://www.g-isbem.com">www.g-isbem.com</a>	SBEM V3.5.a.0 (via iSBEM)	An interface primarily used for graphically enabled building geometry & zone(s) input. Imports constructions, activities & HVAC database from SBEM.	Interfaces to the iSBEM interface rather than the SBEM calculation engine. SBEM limitations apply.
<b>Pro EP Cert</b>	V25.02	Bentley Systems (UK) Ltd	<a href="http://www.bentley.com/en-GB">www.bentley.com/en-GB</a>	SBEM V 3.5.a.0	A cut-down version of Design Database, which has the steady-state calculations removed from the front menu. Uses the same iSBEM interface module as Design Database & Quick EPCert.	The interface is limited by SBEM engine capabilities
<b>Quick EP Cert</b>	V25.02	Bentley Systems (UK) Ltd	<a href="http://www.bentley.com/en-GB">www.bentley.com/en-GB</a>	SBEM V3.5.a.0	A reduced numeric input version of Design Database targeted at Level 3 Energy Assessors. Quick EPCert uses the same iSBEM interface module as Design Database & Pro EPCert.	The interface is limited by SBEM engine capabilities

Table 4.7 contd.: BEPP tools accredited for Part L2A Compliance Calculations-Updated June 2010

Tool	Version	Developer	Website*	Calculation Engine	Description*	Applicability*
<b>FI-SBEM Tools Contd.</b>						
<b>LiveEPC**</b>	V3.5.a	Greenspace Research	www.greenspace-research.com	SBEM V3.5.a.0	Web based building energy performance certificate (EPC) package with online access. Provides an alternative non-graphical interface to SBEM.	The interface is limited by SBEM engine capabilities
<b>Lifespan SBEM gDi</b>	V3.5.a	Chartered Building Surveyors	www.lifespansbem.com	SBEM V3.5.a.0	Web based package with online access. Provides an alternative non-graphical interface to SBEM.	The interface is limited by SBEM engine capabilities
<b>SBEM Online**</b>	V 1.2	NES Ltd.	www.nesltd.co.uk/content/sbem-online	SBEM V3.5.a.0	Web based package with online access. Provides an alternative non-graphical interface to SBEM. Designed for the delivery of Commercial EPCs for level 3 & level 4 existing buildings.	The interface is limited by SBEM engine capabilities
<b>Space Manager</b>	V2.6 (Interface V1.0)	Pythagorus	www.pythagoras.se/	SBEM V3.5.0.a	An object-orientated technology tool used to achieve a coherent model both graphically & in a tabular format in a single database. Interfaces with complete facilities management	The interface is limited by SBEM engine capabilities
<b>VE Virtual Environment PRO</b>	V6.1	IES Ltd, UK	www.iesve.com/UK-ROI	SBEM V3.5.0.a	An SBEM interface incorporated into the VE Suite. Geometry is taken from the <VE> 3D building model. Imports 3D BIM & shares information with ApacheCalc & ApacheSim via VE	Suitable for more complex building forms.
<b>Dynamic Simulation Tools (DSMs)</b>						
<b>Tas Building Designer</b>	V9.1.4	Cranfield Institute/EDSL Ltd	www.edsl.net/	Tas engine V9.1.X (Nov 09)	A DSM that uses a CAD-linked 3D Modeller for building geometry input & modification. Functions such as compliance calculations are performed via a dedicated program Macros.	Suitable for more complex building forms. Not intended for detailed services layout design
<b>VE Virtual Environment PRO</b>	V6.1	IES Ltd, UK	www.iesve.com/UK-ROI	ApacheSim V6.0.5 (Nov 09)	A DSM calculation option incorporated into the VE Suite. Geometry is taken from the <VE> 3D building model. Imports 3D BIM & shares information with ApacheCalc & ApacheSim via VE Integrated Data Model.	Suitable for more complex building forms.
<b>Hevacomp Simulator V8i</b>	V25.0	Bentley Systems Ltd	www.bentley.com/en-GB	EnergyPlus V4.0 (Nov 09)	A DSM calculation option incorporated into the Hevacomp suite. Geometry is taken from the 3D building modeller in Design Database. Includes expanded HVAC design tool options.	Suitable for more complex building forms.

\* All additional information on tools retrieved from developer websites.

\*\* These tools are classified on BECSAS as FI-SBEMs, however, on developer websites their main use is described as EPC production.

#### 4.4.3-User Accreditation Schemes

Two approved accreditation and registration schemes exist to certify user ability in using the appropriate calculation tools for the purposes of the NCM. These are CIBSE Low Carbon Consultant Scheme (LCC) and the BRE Competent Persons Scheme (CPS). Unlike the mandatory procedures for tool accreditation and certification, at the time of writing, these two schemes were non-mandatory and their status was under review by CLG (CIBSE 2010; BRE 2010).

Article 10 of the EPBD includes the requirement that building certification be carried out by qualified and/or accredited experts. This has been applied in the form of mandatory certification schemes for individuals issuing EPCs and DEC's such as the CIBSE Low Carbon Energy Assessors (LCEAs) and BRE Global Accreditation Scheme for Building Energy Assessors-non-dwellings (APEL) and (CIBSE 2010; BRE 2010). Members of both NCM accreditation schemes can optionally upgrade to APEL and LCEA accreditation.

#### 4.5-Potential Issues in the Implementation of the NCM

The legislative integration of energy performance prediction through the implementation of the NCM depends on several factors, the fulfilment of which presents a set of unique challenges to the UK construction industry. A review of relevant literature discussing performance-based building regulations and the use of computer-based tools in the context building energy performance has highlighted several factors that may impede the effort to integrate the use of BEPP tools during the design process and the consequent implementation of the NCM framework.

The CIBSE Guide AM11 (CIBSE 1998) has identified four main areas required for the effective operation of BEPP tools in practice (Elrick 2006). These include; human resource requirements, training, computing environment and quality assurance. These areas provide a framework by which to discuss the potential issues of concern in the legislative integration of energy performance prediction through the implementation of the NCM.

##### 4.5.1-Human Resources and Skills Shortages

Compliance verification within performance-based regulations, pre-supposes a highly-educated, well-informed industry (Olivier 2008; Foliente 2000), usually imposes a larger workload on most individuals involved in the design process and requires more skilled personnel (Varone & Cardillo 2005).

Along with the availability of suitable software, individuals with the required skill sets have been identified as one of the most significant factors affecting this process (Hopkinson & Banks 2006). However, skills shortages have been identified in three areas concerned with the general energy efficient design agenda:

- *General construction sector skills shortage:*

The first of these relates to the general shortage in the required construction industry skills. This includes the lack of multi-skilling and increased compartmentalisation identified in the Egan Report (Egan 1998) and widely discussed in consequent skills assessment reports (e.g. Egan 2002; DCLG 2003). The increased compartmentalisation or specialisation reflects the general trend within the industry that has long seen a growing trend for a design/production and routine/non-routine work division (Cuff 1992).

The Royal Academy of Engineering report 'Engineering a Low Carbon Built Environment' (King 2010) provides the most recent update on this issue and highlights the continued lack of educational infrastructure required to educate new graduates and 'up-skill' professionals in the construction sector. The report also discusses the increased fragmentation in the energy efficient design process, the consequent communication and co-operation failures on key energy efficiency decisions and the absence of recognised codes of practice or professional standards in the field.

- *Modelling skills and expertise:*

The second of these shortages pertains to the specific case of the use of integrated energy performance prediction. The development of new energy prediction tools shows a continuous increase of capabilities and complexity. This increases the dependency on adequate modelling and expertise and the requirement for individuals capable of identifying building features that affect predicted building energy performance (de Wilde 2004) in addition to being able to correctly evaluate and verify results (Donn 1997). This emphasis on narrow areas of knowledge and activity increases vertical disintegration within the design process and creates an increased demand for specialised training, but impacts the long-term ability of individuals to perform other functions.

Findings from previous studies have found that, among others factors, the lack of the required degree of expertise (Hensen 2000) may impede the effort to integrate the use of BEPP tools during the design process. While building designers have the practical knowledge and are aware of the emerging technologies, they are rarely trained in the use of energy prediction tools (de Wilde 2004). While the costs of resources required to establish the required training programs are relatively high, these usually only impose a short run financial burden (Hopkinson & Banks 2006).

- *Enforcement and inspection:*

The third issue pertains to effective inspection and enforcement and is mainly caused by the lack of skilled personnel at local municipalities/authorities (Varone & Cardillo 2005). A survey of building control bodies in the UK concluded that there was a general shortage of trainees in the field (DCLG 2008f) and further studies have shown there to be low compliance with particular aspects of the Building Regulations relating to energy efficiency (DCLG 2008e).

### 4.5.2-Computing Environment

Efforts to increase the usability of energy performance prediction tools have resulted in a more realistic level of understanding of their potential. However, the actual use of these tools to provide information to support the energy efficient design process, in general, does not live up to this expectation (de Wilde 2004).

In the context of performance-based regulations, the various barriers to application regarding the uptake of tools (discussed in detail in section 3.5.1) in effect impedes the integration of compliance verification in the design process. In addition to the fact that many tools lack information about their domain of use and accuracy, the issue of inconsistency in results in this case is particularly important due to the associated regulatory implications and consequent impact regarding industry confidence in the applicability of performance-based standards.

For the specific case of the NCM, there are particular issues concerning the validity of accredited tools. While the default tool SBEM has not been assessed using any of the accreditation procedures specified in section 4.4.2, it is not known if any other procedures have been used to validate it. For the other tool classes discussed (FI-SBEMs and DSMs), the testing procedures used in the accreditation process aim to diagnose and eliminate internal sources of error in calculation algorithms, however an early assessment of a limited number of these tools (Carey 2007) found that it did not necessarily ensure consistency in results.

### 4.5.3-Quality Assurance

Although contemporary programs are able to deliver an impressive array of performance assessments (e.g. Crawley et al. 2008; Hernandez et al. 2008; Xia et al. 2008; Hensen & Augenbroe 2004) in practice, the selection of suitable software does not always guarantee valid results (Kriezis 2004). Various factors such as the possibility of errors within software, mistakes in implementation and/or misapplication may contribute to this. The development of quality assurance procedures and/or frameworks is therefore necessary to instil confidence in the work undertaken and the results produced, by introducing consistency into the implementation process (e.g. Hensen 2008; Reinhart & Fitz 2006; CIBSE 1998).

With regard to the NCM, a number of quality aspects associated with the calculation methodologies were introduced within the framework for the requirements of the EPBD (Dijk 2007a). However, since the framework did not provide similar guidelines for the establishment of a quality control procedure for the validation and verification of the tools (Hensen 2004), validation efforts are therefore undertaken on an individual basis for each member state.

Additionally, while requirements pertaining to the qualification/accreditation of individuals ('Independent Experts') undertaking inspection of boilers and air-conditioning systems is



required by Article 10 of the EPBD (Official Journal of the European Communities 2002), no specific certification scheme is required for users of compliance demonstration tools or the implementation of the process to assure in-use quality.

#### 4.5.4-Legislative Capacity and Coordination

A highly developed and well-resourced regulatory system is required to enable the implementation of the amendments into law and the application of the NCM as a process. The use of a standardised calculation tool-the Standard Assessment Procedure (SAP)-for demonstrating compliance with performance-based regulations for the domestic sector was in place years ahead of the introduction of the approach for the non-domestic sector (ODPM (Later DCLG) 1995). An assessment of the approach highlighted the issues that were experienced in its introduction identifies the shortcomings of the methods used to demonstrate compliance (Lowe & Bell 1998). A further in-depth analysis, discussed the wider implications and argued that a significant improvement in the regulations would be required if the required emissions targets were to be fulfilled (Bell & Lowe 2000).

These findings provide a basis for the challenges expected in the implementation of the NCM for the non-domestic sector. In addition, various issues outlined during the consultation process for the Building Regulations 2006 (ODPM (Later DCLG) 2004) include:

- The considerable evidence pointing to the lack of enforcement of (and compliance with) the previous 2002 Regulations, where variable standards were sought by different Building Control Bodies.
- Concerns regarding variations in the interpretation of procedures of the NCM and associated guidance among various parties.
- The inadequate timescales that were set out for the implementation of the amendments.

#### Chapter Summary:

- The framework for the promotion of energy efficiency is defined by the central government; however, the responsibilities for energy efficiency policies for the various sectors are dispersed and fragmented.
- In the UK, legislation implementation is based on a devolved administration structure subdivided into three jurisdictions (England and Wales, Scotland and Northern Ireland) each governed by a separate body and regulation documents.
- The significant potential for emissions reductions in the non-domestic sector has been recognised.

- The construction of new non-domestic buildings designed to more energy efficient standards can in particular act as exemplars for the encouragement of the uptake of energy efficiency measures and provide an opportunity for exploring a wide scope of energy efficient technologies.
- As part of its commitments as an EU member state, the UK has transposed the requirements of the EPBD into national legislation through the introduction of the Building Regulations 2006 and the National Calculation Methodology (NCM).
- The NCM eliminates alternative compliance routes and emphasises the use of a unified calculation-based methodology for the demonstration of compliance with performance-based standards indicated in terms of CO<sub>2</sub> emissions.
- For the non-domestic sector, the basis of the governmental strategy for the implementation of the NCM included the commissioning of a simplified default calculation tool (SBEM) and the use of two further tool options involving accredited third-party software.
- A review of relevant literature has outlined various potential issues with the implementation of the NCM in practice.

## Chapter 5: Study Methodology

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*This chapter defines the main areas of interrogation of this research and consequently identifies three key parameters as measures by which to assess the viability of the application of the modelling-based approach to energy performance prediction for legislative compliance in practice. Following this, the framework for the conceptualisation and operationalisation of inquiry is outlined and various approaches for conducting research are explored. Accordingly, a research methodology based on a mixed-method design employing both qualitative and quantitative instruments is selected.*

### 5.1-Areas of Interrogation for Research

This research aims to present an objective assessment of the viability and applicability of integrated modelling-based approach to building energy performance prediction for compliance demonstration in the context of performance-based regulations. In particular, the objectives of the study defined in section 1.2 aim to:

- Discuss the potential issues concerning the effectiveness of the NCM as an approach for demonstrating compliance for energy performance.
- Provide an evaluation of the status and adaptability of the UK industry to support the NCM and in addressing subsequent changes.
- Examine the role of key actors, the varying dynamics of application and the potential issues associated with its use.
- Investigate the role of enforcement in checking results and confirming compliance.
- Examine the suitability of accredited building energy performance prediction (BEPP) tools for the purposes of compliance demonstration.
- Investigate the possibility, extent and impact of predictive variability in accredited tools.

In examining the context of the study discussed in Chapter 2, it has been established that the built environment has a significant role to play in achieving national CO<sub>2</sub> reduction targets, where the implementation of a performance-based regulatory approach provides a useful framework that encourages the consideration of energy performance from the earliest design stages. However, the exploration of the use of BEPP tools for building energy performance compliance verification outlined in Chapters 3 and 4 highlighted two main concerns:

- Findings from various studies discussed in Chapter 3 have highlighted factors concerning the associated barriers and risks involved (i.e. barriers to uptake and the issue of predictive accuracy).
- Chapter 4 has related these issues to the particular case of the UK, further highlighting additional challenges concerning the adaptive actions required by industry to establish the required capability for the implementation of the NCM in the context of the Building Regulations 2006.

Accordingly, three key parameters that relate to each of the aforementioned issues were developed as measures by which to assess the viability of the application of the NCM. For each of these parameters, the key assessment criteria can be defined as follows:

*Firstly, the adaptive capability of the UK construction industry:*

- Organisational capability: The establishment of organisational resources to support implementation.
- Skills adaptability: The examination of the role of key actors in the process (e.g. industry professionals and building control) and the assessment of their ability to adequately undertake tasks associated with the implementation of the methodology, verification of results and confirmation of compliance.
- Tool adaptability: The development of suitable software tools and the establishment of a mechanism for the technical accreditation of tools.

*Secondly, the effectiveness of application and enforcement:*

- The applicability of the methodology: The ease of use, practicality and clarity of the NCM as a methodology for compliance demonstration.
- The integration of Part L2A/NCM: The integration of energy performance requirements with other aspects of building projects and its contribution to the energy efficiency agenda.
- The dynamics of the application and enforcement: The effectiveness of implementation and enforcement procedures in practice.
- Issues and areas of priority: Areas of concern in current amendments to the regulations and the definition of priority areas for consideration in upcoming revisions

*Thirdly, the suitability of available tools:*

- Tool usability: The practicality and training required to allow the use of accredited tools.
- Tool capability: The technological capability and consequent applicability of accredited tools to the range of building typologies included in the scope of Part L2A.
- Tool reliability and results variability: The examination of the plausibility of results generated by accredited tools and the reliability of outputs for the purposes of compliance demonstration and beyond.

## 5.2-The Proposed Research Approach: The Mixed-methodology Framework

In exploring the framework for research design, Creswell (2002) describes a process in which the various elements of inquiry conceptualised by the researcher interact to synthesise the research approach. This is then translated into the practical implementation through the use of research instrumentation. In applying this process in practice, it is important to consider the nature of the research problem(s) in the selection of research approach and associated instrumentation that will be required (Brannen 2005). In view of the main goal of the study, the rationale for the selection of the appropriate methodology considered the following aspects:

- Domain of the study: The investigation was conducted in the domain of the built environment, which has conventionally been dominated by a strong quantitative research tradition. However, in this case, the context of research involves a strong human component that required the integration of qualitative methods to investigate underlying aspects such as opinions and perceptions (Amaratunga et al. 2002).
- The research objectives: The objectives of the study suggested that the type of analysis required would necessarily involve the aggregation and combination of data from various sources, groups and actors, and would therefore likely employ various research instruments for data collection.
- Nature of the research subject: The research aims to assess what was essentially (at the time) the application of an emergent approach. Consequently, little initial information concerning its application was available. Additionally, the research subject is also dynamic in nature, involving what were at the time ongoing developments in legislation that were subject to continuous and frequent updating. This presented a challenge in the selection of a research design that ensured that the relevance of the study to these ongoing developments in industry was maintained.

Following an extensive review of literature in the field of research epistemology, the various options outlined in Table 5.1 were considered. In addressing the previous considerations, particularly the emergent and dynamic nature of the research subject, the approach for research was based on the following factors:

- The pragmatic research philosophy described by Creswell (2002) was considered most appropriate since it is both problem-centred and real-world practice oriented.
- The formulation of the research design adopted a mixed-methodology framework where both quantitative and qualitative research techniques and concepts are combined into a single study (Burke Johnson & Onwuegbuzie 2004). Although built environment research has conventionally been dominated by a strong quantitative research tradition, research suggests

that mixed-methodology presents an alternative and, at times, desirable approach to conducting research within built environment (Amaratunga et al. 2002).

- An iterative approach (Yamashita & Bergqvist 2007) was used to refine the methodology, particularly the selection of research instrumentation, as the study progressed.

Table 5.1: Summary of quantitative, qualitative, and mixed-methods approaches  
Source: Yutachom & Khumwong 2004 based on Creswell 2002

Research approach	Knowledge claims	Strategy of inquiry	Method	Use in research
<b>Quantitative</b>	Postpositivist assumptions	Experimental /Quasi-experimental design	<ul style="list-style-type: none"> <li>▪ Predetermined</li> <li>▪ Closed-ended questions</li> <li>▪ Performance, attitude, observation &amp; census data</li> <li>▪ Statistical analysis</li> </ul>	<ul style="list-style-type: none"> <li>▪ Tests or verifies theories or explanations</li> <li>▪ Identifies variables to study</li> <li>▪ Relates variables in questions or hypotheses</li> <li>▪ Uses standards of validity and reliability</li> <li>▪ Observes &amp; measures information numerically</li> <li>▪ Uses unbiased approaches.</li> <li>▪ Employ statistical procedures</li> </ul>
<b>Qualitative</b>	Constructivist assumptions	Ethno-graphic design	<ul style="list-style-type: none"> <li>▪ Emerging methods</li> <li>▪ Open-ended questions</li> <li>▪ Field observation, document data</li> <li>▪ Text &amp; image analysis</li> </ul>	<ul style="list-style-type: none"> <li>▪ Positions himself of herself collects participant meanings</li> <li>▪ Focuses on a single concept or phenomenon</li> <li>▪ Brings personal values into the study</li> </ul>
	Advocacy/ Participatory assumptions	Narrative design	<ul style="list-style-type: none"> <li>▪ Open-ended interview &amp; audiovisual data</li> <li>▪ Text &amp; image analysis</li> </ul>	<ul style="list-style-type: none"> <li>▪ Studies the context or setting of participants.</li> <li>▪ Validates the accuracy of findings</li> <li>▪ Makes interpretations of the data</li> <li>▪ Creates an agenda for change/reform</li> </ul>
<b>Mixed-methods</b>	Pragmatic assumptions	Mixed-methods design	<ul style="list-style-type: none"> <li>▪ Both predetermined &amp; emerging methods</li> <li>▪ Both open- &amp; closed-ended questions</li> <li>▪ Multiple forms of data drawing on all possibilities</li> <li>▪ Statistical &amp; text analysis</li> </ul>	<ul style="list-style-type: none"> <li>▪ Collects both quantitative &amp; qualitative data</li> <li>▪ Develops a rationale for mixing</li> <li>▪ Presents visual picture of the procedure in the study</li> <li>▪ Employs the practices of both qualitative and quantitative research</li> </ul>

### 5.3-The Research Design

Within the mixed-method approach, various models or strategies referred to as *MM typologies* are described (e.g. Burke Johnson & Onwuegbuzie 2004; Creswell 2002; Miles & Huberman 1994; Teddlie & Tashakkori 2006). The determination of the most appropriate of these was undertaken using the process developed by Teddlie and Tashakkori (2006), leading to the selection of a sequential multi-strand mixed-method typology. The characteristics of this variation are:

- The study is conducted over various strands: The research is implemented over multiple phases, alternating between both methods and is therefore referred to as multi-strand (Teddlie & Tashakkori 2006).
- The time order is sequential: Sequential mixed designs involve at least two strands that occur chronologically in a pre-specified order and are employed to answer exploratory and confirmatory questions (Teddlie & Tashakkori 2006).

- The methods have equal status: With regard to the dimension of emphasis, the method adopted considers the quantitative and qualitative components of the research to be of equal importance (Morgan 1998; Morse 1991)

### **5.3.1-Operationalisation of the Research: Methods and Instrumentation**

According to the fundamental principle of mixed-method research (Burke Johnson & Turner 2003), data should be collected using different strategies, approaches and methods in such a way that the resulting mixture or combination builds on the strengths and minimises the weaknesses of the single approaches (Brewer & Hunter 1989; Frechtling & Sharp 1997).

In the context of the mixed-model design used in this research, an industry-based study was first carried out employing both quantitative (survey) and qualitative (in-depth interviews) research instruments. Findings from the industry study indicated that further in-depth assessment with regard to the accredited BEPP tools was required, prompting the expansion of the scope of the study to include a quantitative comparative assessment of tools. The description and aim of each method and associated instruments that were utilised are described below. A more detailed explanation of the process by which each was developed and implemented and a presentation of the results is included in the relevant sections of Chapters 6, 7 and 8.

#### **5.3.1.1-Industry Surveys**

##### **i-Description of method**

Surveys enable the researcher to obtain data (usually several variables) about practices, situations or views in real world environments at specific points in time through questionnaires or interviews. Quantitative analytical techniques are then applied to draw inferences from the data that is gathered on existing relationships (Davison 1998).

As a research instrument, surveys have been widely used as in the wider scope of built environment research and to specifically study the use of computer-based tools in the design process (Altavilla et al. 2004; Mahdavi et al. 2003; Pilgrim et al. 2003). In the context of longitudinal studies, surveys can be designed and implemented to gather data at multiple points over the period of research in order to investigate changes in the unit of analysis (Legg et al. 2005).

##### **ii-Aim of the study**

This study aimed to present an assessment of the adaptive capability of the UK construction industry (the unit of analysis) in establishing the required capability to support the application of the NCM. This was undertaken through the analysis of primary data collected from survey feedback for the purposes of the analysing trend variations during the period covered.

### **iii-Associated instrumentation and implementation approach**

The industry survey study was based on a two-stage format in which the surveys were undertaken at key stages during the implementation of the 2006 amendments (the introductory phase and 1 year after they had been in place) to allow the collection of time-relevant information. Each self-administered survey was conducted through the use of a standard questionnaire published on an online web-based design and hosting platform.

#### **5.3.1.2-In-Depth Industry Interviews**

##### **i-Description of method**

The research interview is a conversation with a structure and purpose determined by the interviewer with the aim of obtaining thoroughly tested knowledge (Kvale 2007). As a method of enquiry, due to its flexibility and capability of producing data that is of great depth (King 1994), in-depth interviewing is the most widely used qualitative enquiry tool in built environment research (Amaratunga et al. 2002).

##### **ii-Aim of the study**

In the context of this research, the general aim of these in-depth interviews was to produce qualitative data describing participants' perception and assessment of their experience of the process from both perspectives. In addition to allowing an in-depth analysis, the data produced from this phase of the study was used for the validation and clarification of the findings of the industry survey results (Amaratunga et al. 2002).

### **iii-Associated instrumentation and implementation approach**

The data collection instrument utilised was a standardised question set 'the interview schedule', this combined both closed-ended and open-ended questions (Tashakkori & Teddlie 2003). The interviews were conducted in a face-to-face setting with the two 'Key Informant' groups of professionals involved in the decision-making process associated with the Part L2A compliance process.

#### **5.3.1.3-Comparative Testing of Tools**

##### **i-Description of method**

Comparative analysis in general relies on the comparison of data, ideally collected according to a common framework (Pickvance 2005). In the particular context of the comparative testing of software tools, this usually involves the analysis of quantitative empirical variables (results) produced by multiple tools.



## ii-Aim of the study

Comparative testing is primarily used for diagnostic or validation purposes. In this study, it used in an exploratory/confirmatory context to provide a comprehensive framework by which to evaluate the suitability of the accredited BEPP tools and investigate the existence and extent of predictive variability reported in industry feedback.

## iii-Associated instrumentation and implementation approach

An inter-model comparative test format using three simplified single-zone physical building variants was selected. To optimise test conditions, measures were taken to ensure the consistency of specification and accuracy of the model input data. The exercises were implemented by a single modeller to minimise user-influenced variability (Guyon 1997).

The incorporation of these research instruments into the mixed-methodology framework is described in Figure 5.1. The conclusions that are made on the basis of the results of the first strand lead to the formulation of questions, data collection, and data analysis for the other strand(s) of the study. These were then conducted to either confirm or disconfirm the inferences of the previous strands or to provide further explanation for earlier findings (Tashakkori & Teddlie 2003). The final inferences were based on the results of all strands of the study. Whilst the undertaking of this type of research design is challenging, it is easier to keep the strands separate and the studies typically unfold more slowly and more predictably (Teddlie & Tashakkori 2006).

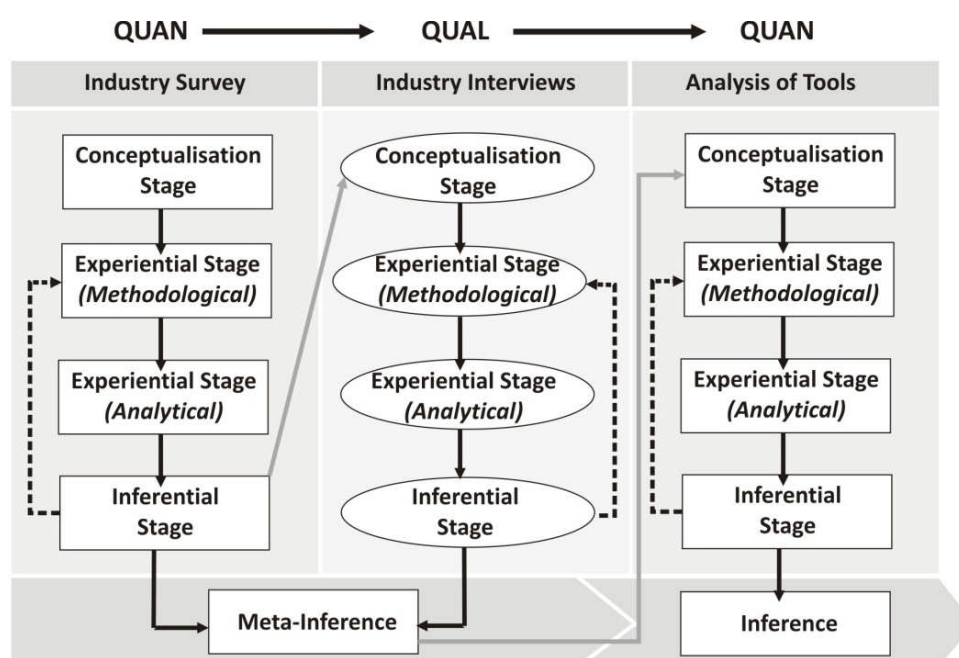


Figure 5.1: Sequential multi-strand mixed-method approach for industry analysis  
Source: Adapted from Teddlie & Tashakkori 2006

### **5.3.2-Data Analysis Procedures and Interpretation Methods**

The use of a mixed-method approach requires the application of various data analysis techniques to address both the quantitative and qualitative components of the research. The methods used in this particular study are discussed briefly below, and the particular aspects of their application are discussed in the relevant sections. The following concepts and approaches were integrated to form the data analysis strategy in this thesis.

#### **5.3.2.1-Micro-Scale Data Analysis Techniques**

Micro-scale (within-phase) analysis techniques are those that were applied with regard to a specific phase of research. Analysis techniques used at the micro-scale are described as follows:

##### **i-Statistical analysis**

Statistical analysis methods were applied in the interpretation of quantitative survey data as well as during the analysis of the tool study outputs. The typology of the data was considered in the selection of appropriate statistical methods, which included (Burke Johnson & Christensen 2004):

- Descriptive statistics: the use of statistics to reveal patterns by describing, summarising, and explaining a given set of data that is comprised of numerical facts or observations. These include frequencies, measures of central tendency, and the degree of dispersion of variables in a sample of a larger population.
- Inferential statistics: the application of procedures used to make inferences (or predictions) from sample data and generalise findings to the population. This involves some form of randomisation in the shape of either random selection or random assignment.

##### **ii-Theory development: The grounded theory approach**

A grounded theory approach (the main characteristics of which are summarised in Table 5.2) was used for theory development in the analysis of the industry surveys and in-depth interviews (Yoong & Pauleen 2004). As a method of analysis, it accepts qualitative, quantitative, and hybrid data collection from various sources (Glaser 1978). Theory is inductively developed from the resulting corpus of data (Borgatti 2006; Hutchison et al. In Press) and rather than testing previously specified theories, novel ideas or hypotheses are generated (Gibbs 2007). In the context of the In-Depth Industry Interviews, grounded theory is one of the most commonly used approaches to coding and analysis (Gibbs 2007) and was therefore also used to produce the framework of analysis for the interview texts.

The application of this approach allows the exploration of the complexity of the problem and can produce a richer and more informative outcome. Here, any propositions that are formulated must be clearly and strongly supported by the data. However, limitations associated with grounded

theory include the complexity and subjective nature of the analysis procedures required and the lack of specific guidance regarding the process of finding patterns in the data (Seaman 1999; Carvalho et al. 2003).

Table 5.2: Key characteristics of the grounded theory approach  
Source: Adapted from Hutchison et al. In Press

Characteristics	Details
<b>An iterative process</b>	A process whereby early data collections & analyses inform subsequent sampling & analytical procedures. The analysis always remains open to new emergent possibilities. This process necessitates concurrent involvement in data collection & analysis phases of the research.
<b>Sampling aimed at theory generation</b>	All sampling decisions made are a function of the research question & ongoing theoretical development. As a result, this approach involves both purposive & theoretical sampling.
<b>Creating analytical codes &amp; categories from the data itself</b>	The analytical process through which concepts are identified & their properties & dimensions are discovered in the data. These should be representative of the data itself & cover a wide range of observations.
<b>Advancing theoretical development throughout</b>	A range of techniques can be used to advance theory development during each step of data collection & analysis. The choice of techniques depends on the epistemological & theoretical stance of the researcher.
<b>Making systematic comparisons</b>	Making comparisons at every stage of the analysis (e.g. within and between cases or over time) helps to establish analytical distinctions by identifying variations in the patterns to be found in the data.
<b>Theoretical density</b>	There must be evidence of theoretical density or depth to the observations presented, resulting in the presentation of a theory from which hypotheses can be generated. This should also include evidence of theoretical saturation (when new data reveals no new theoretical insights).

### ***5.3.2.2-Macro-Scale Methodological and Analytical Integration: Triangulation***

Macro-scale techniques (between phases) are those that are applied to integrate data from various phases. Triangulation forms the main approach adopted at this scale (Table 5.3) and is defined by Flick (2008, p. 40) as when “an issue of research is considered-or in a constructivist formulation is constituted- from (at least) two points”.

This process normally involves data production through the use of different methodological approaches, the combination of which has the potential to validate the findings of all sources (Erzberger & Kelle 2003). Consequently, the application of triangulation is generally seen as a vital validation technique in mixed-methods research (Modell 2009) that increases the validity and strength of the inferences that are made. In this research, this is applied in the following ways:

#### **i-Methodological triangulation**

In this study, the mixed-method approach - a form of methodological triangulation – has been used in the research design (Thurmond 2001). This allows the researcher to reach a maximum of theoretical profit from using distinct methods, thus maximising the interpretative potential of the study (Denzin 2009) and providing greater opportunities for causal inference (Brewer & Hunter 1989) with regard to the challenges that underlie the application of the NCM.

## ii-Analytical triangulation

The concept of triangulation is extended to the data analysis stage where it is applied through the contingent design approach described by Sandelowski et al. (2006) in accordance with the rules of integration formulated by Erzberger and Kelle (2003). The contingent design approach is one of cyclic review where the results of synthesising the findings in the first phase of the study (to answer one research question) determine the nature of the next phase (to answer a second research question) and so on until a comprehensive research synthesis that addresses the research objectives can be presented.

Table 5.3: Key characteristics of triangulation  
Source: Denzin 2009; 2001; Bryman 2002; Brannen 2005b; Morgan 1998; Hammersley 1996

Characteristic	Description
<b>Forms of Triangulation</b>	
<b>Data</b>	Data is gathered through several sampling strategies, so that slices of data at different times & situations, as well as on a variety of people, are gathered.
<b>Investigator</b>	Multiple researchers are used to gather & interpret data.
<b>Theoretical</b>	More than one theoretical position is used in the interpretation of the data.
<b>Methodological</b>	The use of more than one method (e.g. surveys, interviews, documents) for gathering data. Also used in reference to mixed-method research where qualitative & quantitative research is combined.
<b>Scales of Application</b>	
<b>Within-method</b>	The use of varieties of the same method to investigate a research issue, such as using contrasting measurement scales within a questionnaire.
<b>Between-method</b>	The use of contrasting research methods, such as a questionnaire & observation.
<b>Possible Outcomes</b>	
<b>Corroboration</b>	The 'same results' are derived all methods.
<b>Elaboration</b>	Analysis of data from one method exemplifies how the findings from another method apply in particular cases.
<b>Complementarity</b>	Results from various methods differ but together they generate insights.
<b>Contradiction</b>	Data from one method conflict with findings from another.

## 5.4-Quality of the Research: Issues of Validity

The validity of research studies can be differentiated into *design validity*, which pertains to the credibility and trustworthiness of derived conclusions and inferences, and *information validity*, which relies on the quality and reliability of information/data on which the conclusions are based.

The use of mixed-model design requires that measurement techniques and methods for establishing validity for both the qualitative and quantitative elements of the mixed-method research be applied to ensure the overall quality of the study (Lincoln & Guba 1985; Tashakkori et & Teddlie 2003a). When the qualitative or quantitative components are equally significant, Tashakkori and Teddlie (2003) suggest the use of what is referred to as 'inference quality' to convey the quality of the conclusions. Inference quality describes the degree to which the interpretations and conclusions (made on the basis of the results) meet the professional standards of rigor, trustworthiness, and acceptability as well as the degree to which alternative plausible explanations for the obtained results can be ruled out (Tashakkori & Teddlie 2003).

To achieve the required inference quality, the following issues are therefore considered in the analysis of data:

i-*Design quality* is dependent on within-design consistency which refers to the consistency of the procedures of the study from which the inferences are drawn.

ii-*Interpretive rigor* is measured through a number of factors which include:

- Conceptual/inferential consistency: the degree to which the inferences are consistent with each other and with the known state of knowledge and theory.
- Interpretive agreement/consistency: the consistency of interpretations across people (i.e. consistency in participants' perception of reality).
- Interpretive distinctiveness: the degree to which the inferences are distinctively different from (and superior to) other possible interpretations of the results.

## 5.5-Data Protection and Ethical Practice

To ensure that ethical standards towards participants in the various stages of the research were adopted, relevant guidance from the British Sociological Association's Statement of Ethical Practice (BSA 2002) was consulted in the formulation of the ethical protocol during the planning stages of the survey and interview studies. The requirements of the following criteria were fulfilled in the implementation of each:

- **Confidentiality and Participant Anonymity:** Confidentiality in research implies that private data identifying subjects will not be reported (Kvale 2007). In accordance with university guidelines, the research was registered under the Data Protection Act 1998 (UCL Data Protection Registration No Z6364106/2008/6/22, Section 19) under which the obligation to adopt appropriate measures to preserve anonymity and to store interview data in a secure manner were fulfilled.
- **Informed Consent:** Ethical guidelines for social science research commonly concern the subjects' informed consent to participate, which entails informing the research subjects in appropriate detail of the nature of research, the survey/interview procedures, as well as possible risks and benefits (Kvale 2007) that are relevant to their decision to participate (Gibbs 2007). Throughout the preliminary contact stages, all potential survey and interview participants were fully informed of these issues in addition to the right to refuse participation or terminate the survey/ interview (Rapley 2007).
- **Respondent Validation:** For the interview study in particular, validation was sought through a transcript review process (Gibbs 2007), where the transcribed text was sent to the participants for review, feedback and approval.

**Chapter Summary:**

- The three key parameters determined as measures by which to assess the viability of the application of an integrated energy performance prediction approach for legislative compliance in practice are: the adaptive capability of the UK industry, the applicability of the methodology and the suitability of the tools.
- Built environment research has conventionally been dominated by a strong quantitative research tradition. Research suggests that a mixed-methodology presents an alternative and, at times, desirable approach to conducting research within built environment.
- The domain of study, research objectives and nature of the research subject were considered in the selection of the appropriate methodology.
- The framework adopted was a sequential *multi-strand mixed-method* typology, where:
  - The research is conducted over multiple strands;
  - The time order of these research strands is sequential and
  - The (qualitative and quantitative) methods have equal status
- In the context of mixed-method research, both qualitative and quantitative research instruments including surveys, interviews and a comparative analysis were employed.
- The proposed integrated data analysis strategy was applied on two levels :
  - Micro-scale (within-phase) analysis utilised various methods such as grounded theory and statistical analysis.
  - Macro-scale (between phases) analysis adopted the strategy of triangulation to integrate data from various phases.

## Chapter 6: Industry Survey Study-Trends and Adaptability

*In an aim to gauge industry adaptability to the introduction of the NCM and assess the effectiveness of the approach adopted to accommodate the transition in the UK, an empirical exploratory survey-based study was undertaken. The study involved a longitudinal two-stage format, administered at key implementation stages of the methodology to allow the collection of time-relevant information. The following chapter describes the methodology adopted for the implementation of the surveys, presents the results and highlights the major findings and conclusions drawn from them.*

### 6.1-Introduction: The Longitudinal Survey

Surveys have been widely used as a research instrument both in the wider scope of built environment research and to specifically study the use of computer-based tools in the design process (Altavilla et al. 2004; Mahdavi et al. 2003; Pilgrim et al. 2003). In the context of longitudinal studies, surveys can be designed and implemented to gather data at multiple points over the period of research (Legg et al. 2005) to investigate changes in the unit of analysis.

In an aim to assess the adaptability of the UK construction industry (the unit of analysis) in establishing the required capability to support the application of the NCM, industry surveys were undertaken at two key stages during the application of the 2006 amendments (the introductory phase and one year after they had been in place) to allow the collection of time-relevant primary data. Figure 6.1 relates these stages to the overall regulatory implementation timeline. Table 6.1 outlines the particular objectives of each stage and the relevant information that was collected.

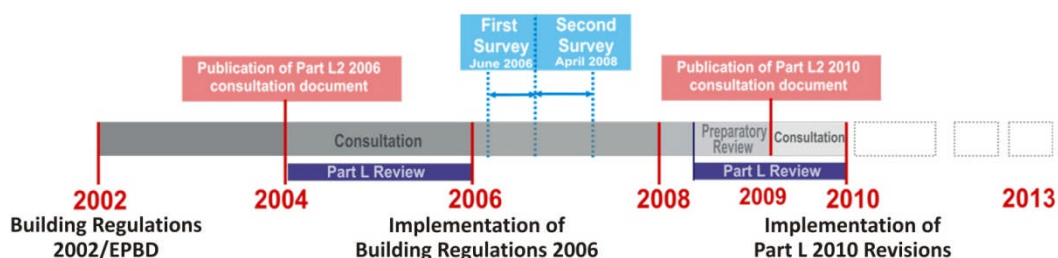


Figure 6.1: Survey timeline

Table 6.1: Outline of survey key stages: Duration, objectives and information

Approach	Period	Objectives	Information
<b>First Survey: Critical Key Stage 1</b>			
Exploratory	June 2006 to December 2006	-Capture a 'snapshot' of the industry during the initial implementation stage -Undertake preliminary investigation of novel research area & develop hypotheses	-Determination of pre-existing industry status -Quantification of impacts & effectiveness of transition policy
<b>Second Survey: Critical Key Stage 2</b>			
Exploratory/ Explanatory	June 2007 to April 2008	-Indicate the relation between variables, by gauging the difference in industry trends after the amendments had been in place for sometime	-Developments in industry capability -Opinions & experiences regarding the transition policy & consequent operational changes

During each stage of the study, only tools that were accredited for implementing the NCM were included in the corresponding survey (Figure 6.2). This variation in the range of accredited tools, in addition to those that have become available since, reflects the developments that have occurred throughout the implementation stages of the 2006 amendments and the continual need to accommodate these changes.

	Survey One	Survey Two	Current Status	
	June 2006 - December 2006	June 2007 - April 2008	2009	2010
SBEM (iSBEM)	Accredited	Accredited	Accredited	Accredited
VE IES	Accredited	Accredited	Accredited	Accredited
TAS Building Designer	Accredited	Accredited	Accredited	Accredited
Carbon Checker	Not Accredited	Accredited	Accredited	Accredited
Design Builder	Not Accredited	Accredited	Accredited	Accredited
Hevacomp Design Database	Not Accredited	Accredited	Accredited	Accredited
VE IES (FI-SBEM Version)	Not Accredited	Not Accredited	Accredited	Accredited
Pro EP Cert	Not Accredited	Not Accredited	Accredited	Accredited
Quick EP Cert	Not Accredited	Not Accredited	Accredited	Accredited
SBEM Lifespan	Not Accredited	Not Accredited	Accredited	Accredited
Cymap	Not Accredited	Not Accredited	Accredited	Accredited
SpaceManager	Not Accredited	Not Accredited	Accredited	Accredited
GI-SBEM	Not Accredited	Not Accredited	Accredited	Accredited
Hevacomp Simulator	Not Accredited	Not Accredited	Accredited	Accredited
SBEM Online	Not Accredited	Not Accredited	Accredited	Accredited
LiveEPC	Not Accredited	Not Accredited	Accredited	Accredited
Lifespan SBEM gDi	Not Accredited	Not Accredited	Accredited	Accredited
G-ISBEM+SiteNotes	Not Accredited	Not Accredited	Accredited	Accredited

Available Tools

Key:   Included in Survey   Not Included in Survey

Figure 6.2: Survey scope

## 6.2-Study Methodology: Survey Design, Procedures and Implementation

The following outlines the approach adopted for the design of the study and the procedures followed in the selection of the participants and the application of the survey.

### 6.2.1-Survey Questionnaire Design and Application

The first survey was based on one standard question set that aimed to collect information through the use of the following questions types described by Kirakowski (2000):



- 1- **Factual-type questions:** to collect observable information concerning the respondent, the workplace and the software used. These were multiple-choice questions where single and on occasion multiple responses or were allowed.
- 2- **Opinion-type questions:** to gauge opinions on the subject (e.g. the tools...etc) and/or situation (e.g. the process of application). These were free text and ranked order questions.

Box 6.1 presents an example of each of these question types that was used in the actual interview question set.

<b>Box 6.1: Examples of question types</b>	
<p><b>Factual-type questions</b></p> <p>In which of the following fields does your organisation employ performance prediction methods? (Please select all applicable fields)</p> <ul style="list-style-type: none"> <li><input type="radio"/> Heating &amp; Cooling Application</li> <li><input type="radio"/> Lighting Applications</li> <li><input type="radio"/> Ventilation &amp; Air Quality Applications</li> <li><input type="radio"/> Building &amp; Room Acoustics</li> <li><input type="radio"/> Fire Safety</li> <li><input type="radio"/> Other (Please specify)</li> </ul>	<p><b>Opinion-type questions</b></p> <p>Please outline any other issues you have encountered in using (tool name):</p> <div style="border: 1px solid black; height: 120px; margin-top: 10px;"></div>

A preliminary draft of questions was pre-tested by a number of experienced practitioners and a final question set was developed (Appendix A-1). The self-administered survey was published on an online web-based design and hosting platform, accessible via an introductory survey homepage detailing the study and outlining the relevance of the research project to industry (Figure 6.3)

A similar process was used in the second survey where feedback from the first survey was integrated into the process of determining the key topics and scope of the interview question set. Here, a separate but essentially identical question set (Appendix A-2) was used for each tool. This enabled the inclusion of in-depth information, while eliminating redundant questions not applicable to users of particular tools. Figure 6.4 outlines the structures of both surveys and the integration of the information produced in each to form the combined inquiries of the study.

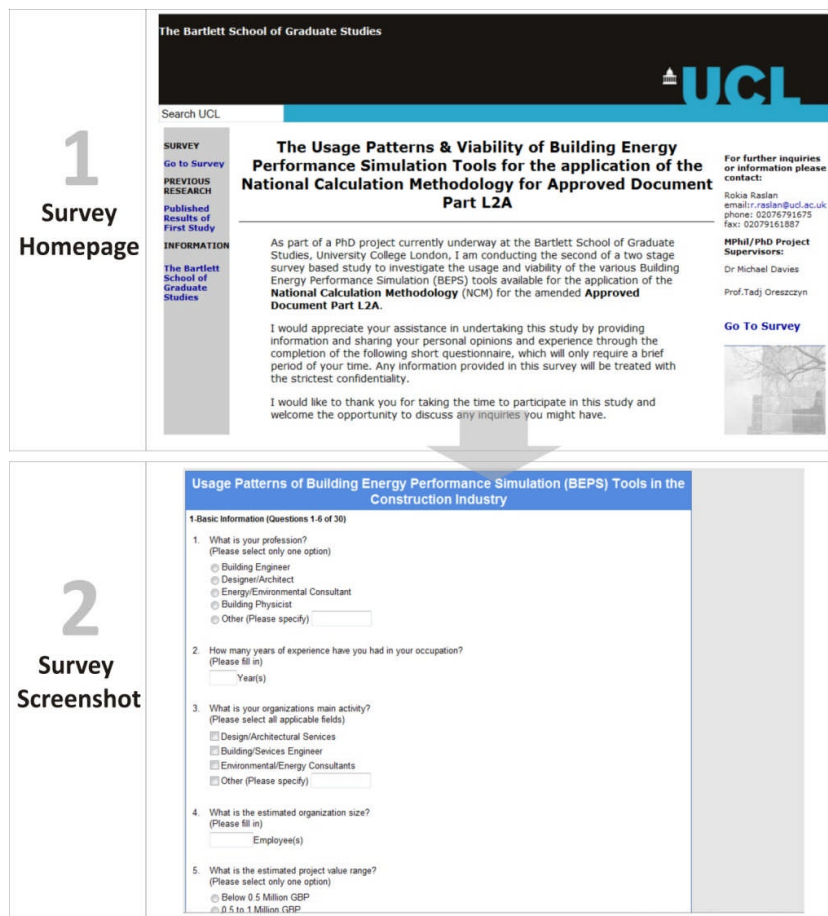


Figure 6.3: Survey online format

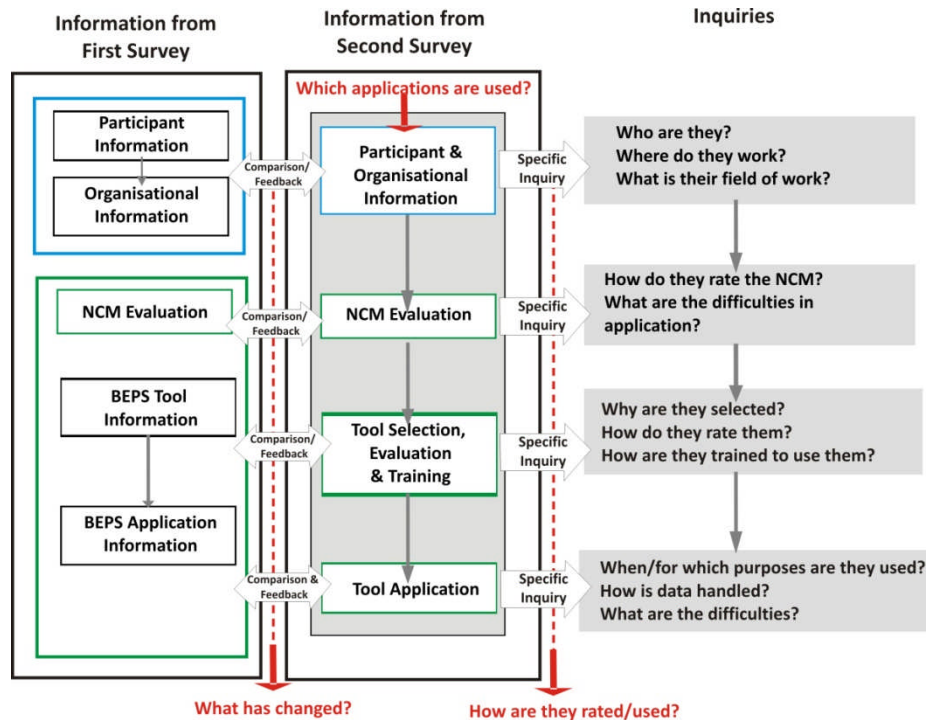


Figure 6.4: Survey structure, information and combined inquiries

## 6.2.2-Respondent Sampling Methodology and Process

Survey research aims to collect data representative of a population and involves the application of procedures that enable the selection of a valid sample of respondents. This allows the generalisation of research findings within the limits of random error to the population from which it is drawn (Kotlik et al. 2001).

### 6.2.2.1-Determination of Sample Size

The determination of an appropriate sample size is integral in establishing the statistical precision with which population values can be estimated (Dattalo 2008). To determine the minimum sample size ( $n$ ), the confidence interval approach was used (Smithson 2003). In this case, the population was assumed to be largely homogenous (i.e. the estimated percent in population  $p=90$ ). A confidence level of 90% (corresponding to a standard error  $z=1.645$ ) and an acceptable sampling error ( $e$ ) of 5% were both deemed appropriate for the indicative nature of the study (Vaus 1996).

The following sample size estimation formula (equation 2) was applied and resulted in the calculation of a minimum sample size of approximately 100 individuals.

#### Box 6. 2: Sample size estimation formula and assumptions

$$n = \frac{z^2(pq)}{e^2} \dots\dots\dots(2)$$

#### Where:

$n$  = the sample size

$z$  = standard error with the chosen level of confidence

$p$  = estimated percent in the population

$q = 100 - p$

$e$  = acceptable sample error

### 6.2.2.2-Sampling Methodology Selection and Application

The selection of the sampling methodology was undertaken after the consideration of both the survey population size and its characteristics. Since one of the main aims in introducing the NCM was to integrate a simple and accessible compliance verification method within the design process, the targeted population ( $N$ ) of survey respondents can in theory be defined as all practitioners in the construction industry operating in England and Wales with potential involvement in the process.

As a starting point, a preliminary review of information from the Construction Industry Council (CIC) resulted in an estimated overall population of 270,000 individuals. This number represents all individuals employed within the sector, where engineering firms employ 17% and architects employ 14% of the total workforce (CIC 2006). The actual target group within the overall

population was defined in accordance with the scope of implementation of the NCM, which involves specific groups such as architects, building services engineers and modelling/simulation specialists. A review of available information outlined in table 6.2, lists approximate membership figures of professional organisations identified as having particular interest in the energy performance agenda (York Consulting 2007; RIBA 2007a; IBPSA 2007). The total of these estimates resulted in an overall target population of over 32,500 individuals.

Table 6.2: Estimation of professional organisation membership

Group	Organisation	Membership
Registered Architects	RIBA	18,601 (Chartered)
Building Services Engineers	CIBSE	14,000
Other	IBPSA-England	100
<b>Total</b>		<b>32,701</b>

In the case of such a large target population where the complete list of all members does not exist, relevant literature recommends the use of a multistage cluster sampling method (Fowler 1993). While this method is not as probabilistic as true random sampling, it is still considered to be effective as it builds on multiple randomisations that allow the comprehensive and efficient investigation of large target populations. Figure 6.5 illustrates the framework and stages of the methodology as applied in this particular study:

- **Stage 1: Determination of initial clusters within the survey population:** These were identified as the previously mentioned professional groups including architects, building services engineers and simulation specialists.
- **Stage 2: Determination of sampling clusters within initial clusters:** To increase the representativeness of the sample (Vaus 1996) the clusters included a range of organisations, which the professional groups were likely to be affiliated. These included the Royal Institute of British Architects (RIBA), Bartlett School of Graduate Studies - Environmental Design and Engineering group (BSGS-EDE) and a global consulting firm (both surveys) in addition special interest and professional groups such as IBPSA-England, CIBSE and several commercial consultancies and companies (second survey).
- **Stage 3: Selection of respondents from within clusters:** An element-level sample frame for the selected clusters was compiled. After considering that the response rate (Fowler 1993) in similar studies was approximately 28% (Lam et al. 1999), it was determined that a frame of approximately 500 individuals would be required to ensure that the minimum calculated sample size was achieved. Accordingly, a database was created from within these groups and contacted via email and company intranet invitations.

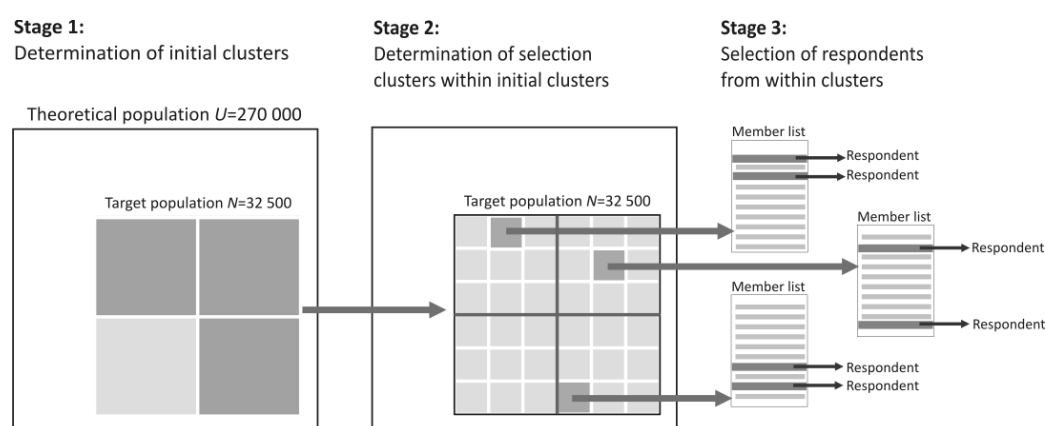


Figure 6.5: Implementation of the multistage survey sampling methodology

### 6.2.3-Response Rate and Limitation of Bias

For both surveys over 280 forms (total responses) were submitted. All valid responses that were usefully complete and contained relevant feedback (although not necessarily fully filled) were considered. Respondent statistics (Table 6.3) show that since valid responses exceeded the minimum required sample size and response rates conformed to the range found in similar studies (Altavilla et al. 2004; Mahdavi et al. 2003; Pilgrim et al. 2003), the size of the sample can be considered sufficient to be representative of the survey population ( $N$ ) (Vaus 1996). Furthermore, the sample size also equates to almost 50% of the individuals that were included on relevant accreditation scheme membership lists at the time (BRE 2007; CIBSE 2008), even though results showed that not all respondents were necessarily members.

Research bias is described as a systematic error (Ayyub & McCuen 2003; Weisberg et al. 1996) or deviation from the truth, which can undermine both the reliability and validity of research inferences and consequent results (Fowler 1993). To reduce the sampling bias that results in sampling errors, the previously mentioned steps were taken to ensure the inclusion of an adequate sample size and the selection of a suitable sampling methodology. The reduction of the likelihood of non-sampling bias and consequent non-sampling errors which are associated with research design problems and non-response was addressed through the use of measures such as the choice of study design, the standardisation of information collection instruments and procedures. With the combination of these measures, it can therefore be assumed that results are free from significant error.

Table 6.3: Survey response statistics

	First Survey		Second Survey	
	No. of Responses	Response Rate	No. of Responses	Response Rate
<b>Total Responses</b>	139	28%	147	29%
<b>Valid Responses<sup>1</sup></b>	122	24%	124	25%
<b>Fully Complete Responses<sup>2</sup></b>	50	10%	67	13%

<sup>1</sup>Valid responses are usefully complete, though not necessarily fully filled. All valid responses were included.

<sup>2</sup>Complete responses are those which are fully filled.

### 6.3-Comparative Analysis of Survey Results

A quantitative descriptive approach (Miles et al. 1994) was predominantly used for the analysis of survey data. This data mainly consisted of categorical variables that were mostly polytomous<sup>10</sup> nominal/ordinal type. Free text feedback portions were first coded (Miles et al. 1994), then analysed in the same manner.

Since the data gathered was non-continuous, the opportunity for the application of statistical techniques was limited. To explore the existence of significant relationships between variables, relevant guidelines for selecting appropriate measures of association (Mehta et al. 2008; Mehta et al. 2004; Vaus 1996) were followed.

The results were then finally grouped into sections that were predominantly defined by the structure of the survey question sets. The following presents the key findings of each of the sections. The results on which they were inferred are discussed and-where relevant- the related survey response data is included in tabulated form.

#### 6.3.1-Respondent and Organisational Profile

**The key findings from this section are:**

- *A change in occupational and organisational trends from design to technical based profession.*
- *Organisation size grew considerably.*
- *A significant variation existed between surveys with regard to the relationship between organisational size and the tool used.*
- *Through the initial stage of implementation of the methodology, most users were relatively less experienced newer graduates.*

##### 6.3.1.1-Respondent Occupation

Table 6.4 illustrates that the majority of first survey respondents (47%) were architects, followed by environmental consultants (21%), building engineers (18%) and building physicists (5%). The majority (58%) had less than 10 years of experience in the construction sector. The mode value for respondents was 5 years (14%), suggesting that the field of energy performance attracted relatively newer graduates.

In contrast, results from the second survey show a distinct shift where the majority of respondents were either building engineers (33%) or environmental consultants (23%). A comparison of the percentage change in occupational category distribution between both surveys shows a trend

<sup>10</sup> A polytomous variable is that where there is more than one possible outcome (Christensen 1996). A polytomous response is one that is restricted to one of a fixed set of possible values (McCullagh & Nelder 1989)

change towards more specialised technical occupations. Building services engineers in particular increased by 15% and architecture/design occupations decreased by 29%. Additionally, results also suggest the existence of an occupation-specific trend regarding tool preference; whereas users of SBEM were evenly distributed throughout the occupational categories, users of the most popular DSM class tool (IES) belonged to technical professions (engineers and physicists) and users of the Hevacomp interface were almost exclusively building engineers.

Table 6.4: Comparative responses to “What is your profession?”

	% of Respondents		% Change Between Surveys
	First Survey	Second Survey	
<b>Designer/Architect</b>	47%	18%	-29%
<b>Building Services Engineer</b>	18%	33%	+15%
<b>Energy/Environmental Consultant</b>	21%	23%	+2%
<b>Building Physicist</b>	6%	13%	+7%
<b>Other</b>	8%	13%	+5%

### 6.3.1.2-Organisational Profile

Table 6.5 outlines the shift in organisational activity that occurred between both surveys. Most respondents in the first survey worked for large companies specialising in architectural design (44%) building services engineering (31%) and environmental technical/consultation (17%). In the second survey, building services engineering firms were by far the major employer (43%) followed by multi-disciplinary organisations (24%).

Table 6.5: Comparative responses to “What is your organisation’s main activity?”

	% of Respondents		% Change Between Surveys
	First Survey	Second Survey	
<b>Design/Architectural Services</b>	44%	14%	-30%
<b>Building Services Engineering</b>	31%	43%	+12%
<b>Environmental/Energy Consultant</b>	17%	13%	-4%
<b>Multidisciplinary</b>	N/A	24%	+24%
<b>Other</b>	8%	7%	-1%

Organisational size statistics summarised in

Table 6.6 shows that the mean size of organisations increased significantly-by about 40%- between surveys. The analysis also highlights the considerable variability of organisation size between tools. Users of the SBEM and IES generally worked for large companies, with a mean organisation size of approximately 1000 and 2300 respectively. Tas and Hevacomp users worked in smaller companies with a mean size of around 500 employees and Carbon Checker users worked for small offices of around 20 employees.

Table 6.6: Summary statistics of organisation size: Responses to “What is the estimated organisation size?”

	First Survey	Second Survey					
		All	SBEM	IES	Tas	Carbon-Checker	Hevacomp
Mean	969.73	1367.61	1046.05	2322.25	509.37	23.57	441.42
Median	130.00	100.00	100.00	1000.00	40.00	7.00	32.50
Mode	200	50	3500	50	25	5	15
Std. Deviation	2049.878	2524.209	2021.860	3277.606	1343.390	42.669	1008.057
Minimum	1	1	1	3	3	5	7
Maximum	13000	12000	10000	12000	5000	120	3500

### 6.3.1.3- Project Profile

With regard to project profiles, both surveys show a consistency in trends. Domestic projects constituted less than 25% and non-domestic projects collectively more than 75% of work undertaken in the organisations (Table 6.7). The leading non-domestic sector in both surveys was commercial (retail/offices) buildings. Educational and healthcare buildings also constituted a significant portion of non-domestic projects in the first and second surveys, respectively.

Table 6.7: Comparative responses to “Which of the following project types does your organisation most frequently undertake?”

	% of Respondents		% Change Between Surveys
	First Survey	Second Survey	
Residential	23%	21%	+2%
Commercial (Retail/office)	25%	29%	-4%
Cultural (Museum/Library)	11%	11%	0%
Healthcare	12%	19%	-7%
Educational	21%	13%	+7%
Other	8%	6%	+2%

### 6.3.2-General Patterns of Software Use

The key findings from this section are:

- *Building energy modelling is still a specialised function in the design process that has yet to be fully integrated.*
- *Building energy modelling is not used when it is most influential to the design process.*

A comparison of the frequency of use of the range of software types (Table 6.8) indicates that there was a large base of 2D CAD users on both respondent (46%) and organisational (69%) scales. There were considerably fewer users of 3D CAD, lighting and project management applications (1.5-6%). However, while a large number of respondents (34%) reported that they had used BEPP tools, within organisations the use of BEPP tools was, in general, very rare (1%).



Table 6.8: Combined responses to “Which software applications do you most frequently use?” and “Which software applications are most frequently used in your organisation?”

Software Type	Respondent	Organisation
2D CAD Software	46%	69%
3D CAD Software	6%	10%
Architectural Visualisation/ Modelling	1%	2%
Lighting Software	1%	14%
BEPP Software	34%	1%
CFD Applications	1%	1%
Project Management Applications	3%	1%
Other	7%	2%

Significant differences were also reported with regard to when various software types were used during the design process. Results from the first survey (Figure 6.6) show that general construction related software was most frequently used during the design development stage and the preparation of construction documents, with the highest percentage of respondents reporting that it was ‘always used’.

Despite the specialisation of respondents in this field, by comparison BEPP tools were mostly only ‘frequently used’ during the same design stages. During the earlier design stages (e.g. schematic design), where performance prediction is widely considered to be most effective in informing design decisions ( e.g. Bradley 2009; Cutler et al. 2008; RIBA 2007), use was notably less frequent.

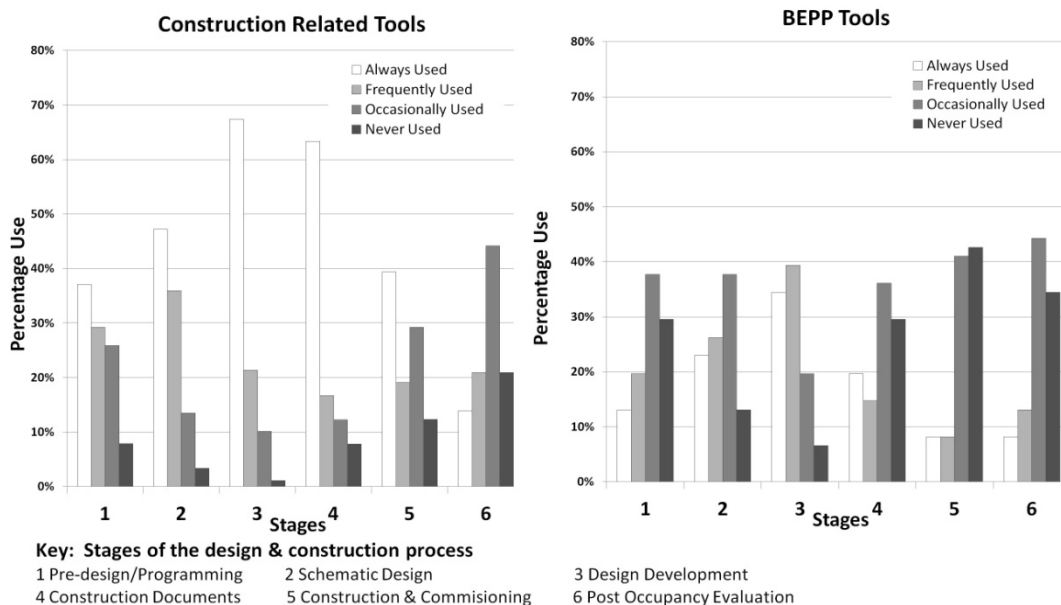


Figure 6.6: Responses to “Rate the frequency of use of construction related and BEPP software in your organisation during each of the following phases of the design/construction process” showing comparative frequency of tool use.

Figure 6.7 represents the compilation of the ranked order data concerning the use of the various methods of energy performance prediction. This was based on data from a question included in the first survey that aimed to interrogate initial industry perspectives regarding the acceptability of the use of computer-based modelling/simulation for energy performance prediction.

Results show that traditional techniques based on engineering experience and design guidelines were more frequently used despite there being a consensus that computer simulation results were more reliable. In relating these responses to the data from Table 6.8 and Figure 6.6, it can be suggested that the relatively limited use of computer-based BEPP tools can be attributed to this perceived difficulty in using computer-based tools.

	Frequency of Use				Reliability of Results				Ease of Use			
	High	Low			High	Low			High	Low		
Rank	1	2	3	4	1	2	3	4	1	2	3	4
Engineering Experience	x							x	x			
Rules of Thumb		x					x			x		
Design Guidelines			x			x					x	
Computer Based Energy Simulation				x	x							x

Figure 6.7: Responses Matrix for “Rank the following energy performance prediction methods according to the factors stated below (1=highest, 4=lowest)”

### 6.3.3-Energy Performance Prediction Compliance Demonstration Tools

#### The key findings from this section are:

- During the initial implementation stage, a large percentage of respondents used non accredited tool.
- Increased tool accreditation did not considerably impact use patterns.
- A relationship between tool used and occupation was observed.
- Tool use was increasingly limited to Part L2A calculation.
- Tool reliability was consistently cited as an important factor in the selection of BEPP tools used for general energy performance calculations and accredited for Part L2A calculations.
- Software modelling difficulties/inconsistencies and data entry procedures were generally considered to be the main concern for all tools.

### 6.3.3.1-Tool Use

During the initial implementation stages of the NCM, the three major tools used by respondents (SBEM, IES and Tas) were all accredited. However, 42% of respondents reported that they also used or intended to use other non-accredited tools such as Hevacomp (which has since been accredited), ESP-r, EnergyPlus and a variety of in-house developed tools.

In the second survey, the accreditation of a wider variety did not greatly affect this distribution. The initial three tools still dominated the market (Figure 6.8) despite the accreditation of Hevacomp and Carbon Checker FI-SBEM class tools, which were only able to gain 9% and 11% of the market share, respectively.

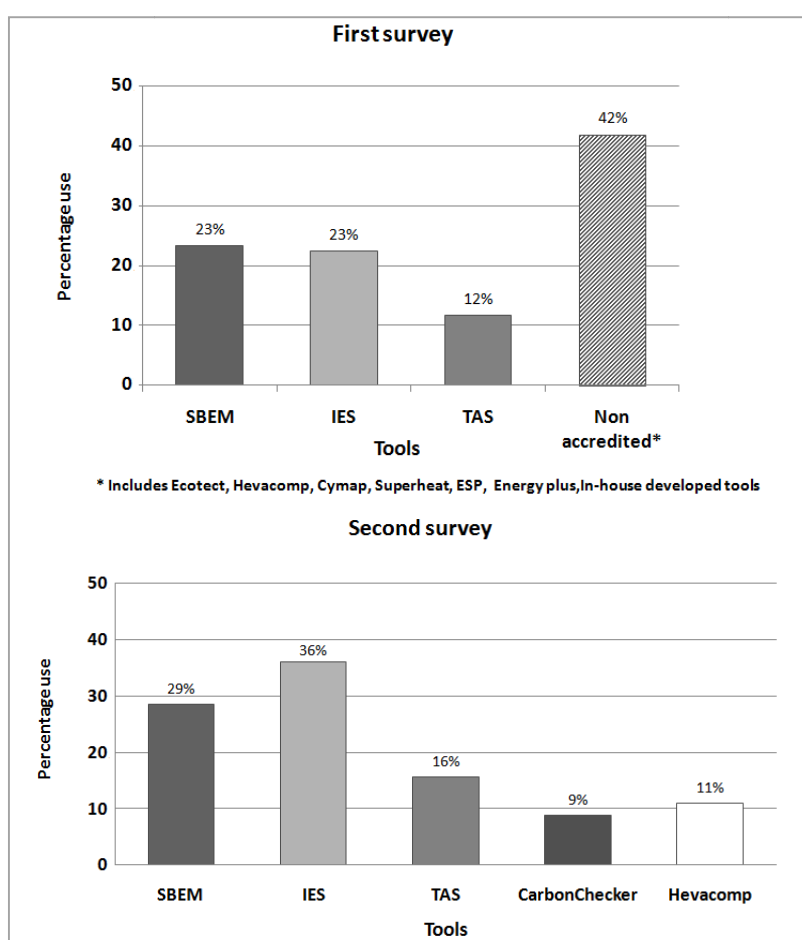


Figure 6.8: Comparative responses to "Which of the following BEPP tools are you using or intend to use for Part L2A compliance?"

### 6.3.3.2-Tool Use Patterns

In both surveys, the majority of Part L2A calculation work was undertaken by building service engineers (approximately 45%). Specialised teams in the form of both in-house (25%) and outsourced (8-14%) groups were also significantly involved (Table 6.9). The involvement of project designers/architect remained low throughout both surveys.

Table 6.9: Responses to "For projects undertaken by your organisation, who is usually responsible for Part L2A compliance calculations?"

	First Survey	% Respondents					
		Second Survey					
		Total	SBEM	IES	Tas	Carbon Checker	Hevacomp
<b>Project Designers/Architects</b>	12%	17%	26%	12%	6%	33%	10%
<b>Building Services Engineers</b>	46%	47%	43%	43%	44%	33%	90%
<b>*In-House Simulation Group</b>	26%	25%	14%	36%	39%	17%	0%
<b>*External Consultant (outsourced)</b>	14%	8%	12%	5%	11%	17%	0%
<b>Other</b>	2%	3%	5%	5%	0%	0%	0%

\* Specialised Teams

To test the hypothesis that a relationship existed between respondent occupation and the tool used, data concerning both was cross-tabulated and a Chi-Square<sup>11</sup> non-parametric test of association was implemented.

- Tool used/Occupation: The test result is expressed as  $\chi^2=34.476$ ,  $df=12$ , where the significance level<sup>12</sup>  $q=0.001$  indicates a significant assumed association ( $q<0.05$ ) (Mehta et al. 2004). By analysing the cross-tabulated data, specific trends confirming this were observed. For example, users of the Hevacomp interface and IES tended to belong to more technical professions such as building engineers or building physicists.

To further elaborate on potential patterns, a further breakdown of tool use with regard to both organisational activity (Table 6.10) and project type (Table 6.11) was tabulated and a Chi-Square test was implemented for the results of the second survey for each. The test results were:

- Tool used/Organisational activity:  $\chi^2=31.664$ ,  $df=16$ , where the significance level  $q=0.011$  indicates that an association exists between these two factors, even though it is less significant than that previously described for the occupation/tool relationship. With some tools such as the Hevacomp interface, this pattern is very apparent, where its use is almost confined to building services design firms (75%). This may be attributable to the fact that the interface is included within the Hevacomp MEP systems design suite of software.
- Tool used/Project type:  $\chi^2=22.307$ ,  $df=20$ , where the significance level  $q=0.324$  indicates that no association exists between these two factors.

<sup>11</sup> In cases such as this where some of the expected cell count frequencies fall below 5, a Fisher's Exact test which calculates the exact  $q$  value is preferred. However, this test was not performed due to computational limitations (insufficient memory). The less memory-intensive Monte Carlo method recommended in relevant literature with a 99% confidence interval was instead used. The validity of the results of this test is confirmed through an analysis of the cross-tabulated data as mentioned above.

<sup>12</sup> The significance level denotes the probability of an observed result happening by chance under the null hypothesis.

Table 6.10: Breakdown of main organisational activity/tool used

	% Respondents						
	First Survey	Second Survey					
		Total	SBEM	IES	Tas	Carbon Checker	Hevacomp
Design/Architectural Services	44%	14%	24%	7%	10%	29%	8%
Building/Services Engineer	31%	43%	34%	42%	55%	0%	75%
Environmental/Energy Consultant	17%	13%	13%	9%	15%	57%	0%
Multidisciplinary*	-	24%	24%	33%	10%	14%	17%
Other	8%	7%	5%	9%	10%	0%	0%

\* This category was added in the second survey based on feedback from the first, where many used the category 'other' to denote a multidisciplinary organisation

Table 6.11: Breakdown of project type/tool used

	% Respondents						
	First Survey	Second Survey					
		Total	SBEM	IES	Tas	Carbon Checker	Hevacomp
Residential	23%	21%	26%	14%	20%	40%	24%
Commercial (Retail/office)	25%	29%	32%	26%	30%	50%	26%
Cultural(Museum/Library)	11%	11%	10%	13%	14%	0%	7%
Healthcare	12%	19%	18%	22%	18%	0%	21%
Educational	21%	13%	10%	18%	8%	0%	19%
Other	8%	6%	4%	7%	10%	10%	2%

Although Figure 6.8 illustrated the continued market dominance of the three major tools, data outlined in Table 6.12 suggests that with the availability of an increased number of accredited tools, the majority of respondents had experience with multiple tools. While the freely available SBEM was understandably the most popular alternative tool choice, however users who predominantly used it were less likely to use other tools.

Table 6.12: Responses to "Have you used any of the following tools for Part L2A calculations?"

	% of Respondents				
	SBEM	IES	Tas	Carbon Checker	Hevacomp
No	48%	15%	12%	0%	14%
SBEM	N/A	55%	41%	100%	57%
IES	16%	N/A	18%	100%	14%
Tas	6%	13%	N/A	100%	0%
Carbon Checker	3%	5%	12%	N/A	14%
Hevacomp	19%	10%	18%	100%	N/A
Other	6%	3%	0%	100%	0%

With regard to the scope of tool use, Table 6.13 outlines use trends beyond Part L2A calculations. Results suggest that while a considerable percentage of respondents continued to use tools for general (non-regulatory) energy performance applications, there was an increased specialisation in confining the use of tools to Part L2A calculations, which increased 6% between surveys.

Table 6.13: Comparative responses to “In addition to Part L2A, for which of the following purposes do you use BEPP tools/the selected tool for?”

	% of Respondents		% Change Between Surveys
	First Survey	Second Survey	
Improving Overall Energy Performance	32%	27%	-5%
Estimating & Minimising Overheating	27%	20%	+7%
Producing Client Reports	20%	19%	-1%
Research Purposes	14%	13%	-1%
No Other Purposes	4%	10%	+6%
Other	3%	10%	+7%

### 6.3.3.3-Tool Selection

Respondent data from the first survey (Table 6.14) orders BEPP tool selection determinants in terms of importance. Responses show that plausibility (the ability to produce logical results) and reliability (the ability to produce consistent results) were prioritised as the main determinants in the selection of specific tools.

For the second survey the response matrix describing the impact of selection determinants for Part L2A accredited tools is described in Table 6.15. While reliability in particular was almost consistently rated as ‘very important’, results also show that the importance of other factors varied for each tool and between tool classes. For example, for free or low cost-tools (e.g. SBEM and Carbon Checker) financial affordability was the major contributing factor, while for the more expensive tools (e.g. IES) modelling capability and the plausibility of the results were considered to be more significant.

Table 6.14: Rank order of factors from responses to “Rank the following factors in terms of their importance in the selection of software/BEPP applications for use in your organisation”

Factor	Tool	
	General Software	BEPP Tools
Decreasing Importance ↓	1 Required Use	Plausibility of Results
	2 Plausibility of Results	Reliability/Stability
	3 Financial Affordability	Financial Affordability
	4 Reliability/Stability	Technical Support
	5 Availability	Required Use
	6 Technical Support	Ease of Use
	7 Ease of Use	Availability

Table 6.15: Response matrix of results for “Rate the importance of the following factors in your selection of (accredited tool) for Part L2A energy compliance calculations”.

	Tool				
	SBEM	IES	Tas	CarbonChecker	Hevacomp
Financial Affordability	2	3	3	2	2
Ease of Use	2	2	1/2	1	1/2
Availability of Technical Support	2	2	2	1/2	1/2
Reliability/Stability of tool	2	1	1	1	1
Plausibility of Results	2	1	2	1/2	1/2
Modelling Capability	2	1	2	1/2	1
Key: Rating Scales	1 - Very Important	2 - Important	3 - Less Important	4 - Not Important	

### 6.3.3.4-Tool Assessment and Issues

Users were given the opportunity to provide feedback in a free-text section with regard to issues encountered in using their selected tool. The detailed feedback is listed in Appendix B. A simple coding approach involving the identification of themes and the assignment of keywords to the response segments was applied to show the frequency of the occurrence of specific issues within the various tool classes. The results of this analysis are summarised in Table 6.16.

Table 6.16: Tabulated data of coded responses to “Outline any issues you have encountered in using (tool name)”

		Tool			
		SBEM	DSM	FI-SBEM	Total
No Issues Reported		45%	41%	50%	
Issues Reported		55%	59%	50%	
	Data entry Procedures	18%	18%	25%	18%
	Modelling Difficulties and inconsistencies	47%	47%	25%	46%
	Software errors and compatibility	8%	12%	25%	11%
	Results validity	18%	15%	0%	16%
	Technical support and training	5%	6%	0%	5%
	NCM Compatibility	3%	3%	25%	4%

Results suggest that software modelling difficulties/inconsistencies and data entry procedures were generally considered to be the main concern for all tools. Specific issues were associated with particular tool classes, for example, the difficulty and confusion arising from the non-graphical data entry forms in iSBEM, interoperability/backwards compatibility issues and consequent results variability between different versions for DSMs and difficulties in importing drawings from client models and the results production time for FI-SBEMs.

### 6.3.4-The National Calculation Methodology

#### The key findings from this section are:

- *The previously used Carbon Emissions Method version (from the Building Regulations 2002) on which the NCM was based on was the least popular of compliance methods.*
- *The opinion of respondents regarding the NCM was generally low and only improved slightly between surveys.*
- *The choice of tool impacted on respondent assessment of the efficiency in applying the NCM.*

For the previous version of the Building Regulations (2002), of the three methods used for Part L2A compliance demonstration, the Elemental Method was generally the most popular (45%) (Figure 6.9). The Carbon Emissions Method on which the NCM was based was in general the least popular. However, a detailed breakdown of results indicate, that in general, DSM tool users were more likely to have preferred to use the Carbon Emissions Methods than SBEM or FI-SBEM users.

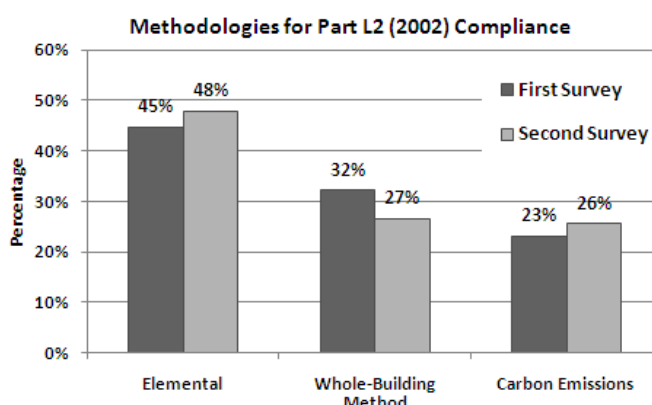


Figure 6.9: Responses to “Which of the following methods did you previously most frequently use for Part L2A compliance demonstration?”

Respondents’ feedback of the NCM (Table 6.17) during the initial stage of implementation, rated it as ‘unsatisfactory’ in almost all assessment categories. Over a year after its introduction, a slight overall improvement to a ‘satisfactory’ rating was observed. However, approximately half of the respondents still encountered difficulties in applying it. Two important observations that can be made with regard to the particular assessment categories in each of the surveys are:

- In the first survey, methodology usability and efficiency were the categories most rated as ‘unsatisfactory’ by respondents.
- In the second survey, validity was by far the category where the largest percentage of respondents had felt that the methodology was ‘unsatisfactory’.

This suggests that while increased experience may have lead to respondents becoming more familiar with the NCM, it also lead to an increased scrutiny of its validity.

Table 6.17: Comparative responses to “Rate your experience with using the National Calculation Method (NCM) as a compliance methodology for Part L2A in terms of the following factors”

	% Respondents							
	First Survey				Second Survey			
	Very Good	Good	Satisfactory	Un-satisfactory	Very Good	Good	Satisfactory	Un-satisfactory
Clarity	4%	22%	36%	38%	5%	16%	45%	33%
Usability	2%	14%	40%	44%	7%	22%	50%	22%
Validity	2%	14%	51%	33%	6%	17%	42%	36%
Flexibility	4%	22%	46%	28%	5%	28%	37%	29%
Efficiency	2%	10%	49%	39%	5%	26%	36%	32%
Reliability	2%	14%	56%	28%	7%	16%	50%	28%

To test if tool choice had affected respondent assessment of their experience in applying the NCM, a Chi-Square test was implemented. Results indicate that there was no association (where  $p > 0.05$ ) for almost all the assessment categories. The exception to this was the perceived efficiency of the NCM (i.e. how efficient was the procedure was in producing compliance demonstration results) where  $p = 0.043$ . Observation of the cross-tabulated results confirmed this, where users of Tas and Carbon Checker rated NCM efficiency higher (good) than SBEM users (unsatisfactory).



### 6.3.5-Reliability of Results and Quality Control

The key findings from this section are:

- *Tool-based results variability was reported.*
- *User tool proficiency and familiarity are significant in achieving compliance.*
- *The application of output validation methods is still insufficient.*

Table 6.18 data summarises the responses to two questions intended to interrogate the existence of results variability between tools. The data shows that in the majority of cases where multiple tools were used to run the same building, respondents reported some variability in results. Invariably, respondents cited that the most favourable results were achieved using their preferred tool. This suggests that user proficiency and familiarity with the tool, rather than actual tool features, are the most significant factors in achieving compliance.

Table 6.18: Combined responses to “Did you find there to be significant differences in results?” and “Which tool gave the most favourable results with regard to achieving Part L2A compliance?”

	% Respondents				
	SBEM	IES	Tas	Carbon Checker	Hevacomp
No	43%	13%	38%	100%	100%
Yes	57%	87%	63%	0%	0%
SBEM	29%	22%	13%	50%	0%
IES VE	29%	43%	0%	0%	0%
EDSL Tas	14%	4%	75%	0%	0%
Carbon Checker	7%	9%	0%	50%	20%
Hevacomp	7%	0%	13%	0%	80%
Other	14%	22%	0%	0%	0%

Even though frequent inconsistencies in results were reported, as illustrated in Figure 6.10, over 7% of first survey and 18% of second survey respondents did not undertake any form of output validation. Nearly half employed either multiple self-checks or multiple user checks for validation, while only 5% relied on benchmarks or independent testing by QA experts.

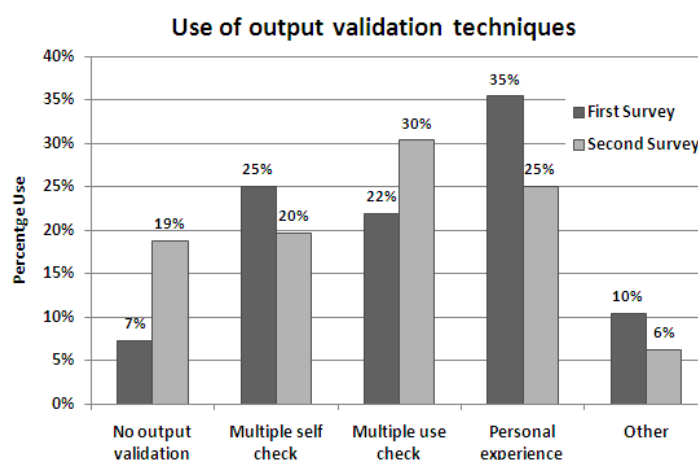


Figure 6.10: Responses to “Which of the following methods do you use to validate output from (energy) simulation exercises?”

### 6.3.6-User Training and Certification

The key findings from this section are:

- Uptake of formal training was low and a general growth in the reliance on self-instruction was observed.
- Over half of all respondents had not participated in any certification program.

#### 6.3.6.1-Training

Although 40% of first survey respondents had undergone some sort of formal training, a considerable percentage had relied on self-instruction (33%) or peers/colleagues (16%) (Figure 6.11). Results from the second survey show that there was a general growth in the reliance on self-instruction. Externally provided formal training was more prevalent in the case of DSMs (17-25%), where its costs are often incorporated into license acquisition/subscription fees. The perceived quality of the training received varied considerably between tool users, however almost 14% of respondents stated that they considered the training they received to be 'unsatisfactory' (Table 6.19).

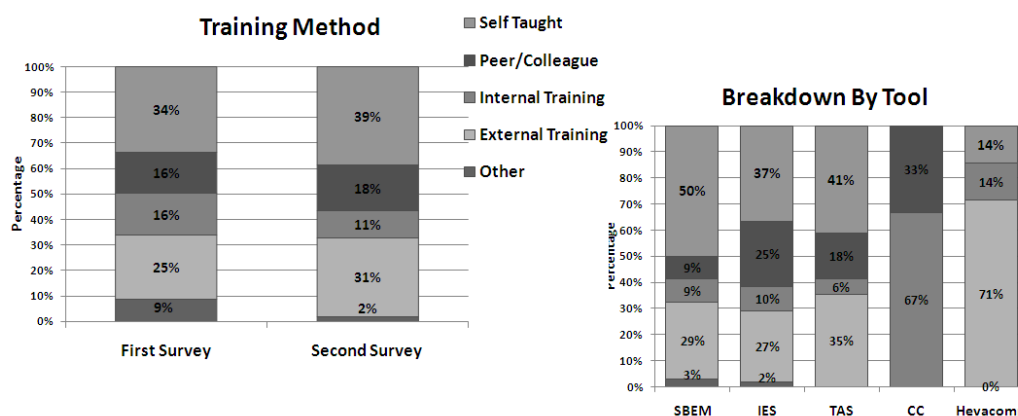


Figure 6.11: Responses to “Which of the following methods are used to provide information and training concerning changes to Part L2A and the application of the NCM in your organisation?”

Table 6.19: Training assessment by tool: Responses to “How do you rate the effectiveness and adequacy of this training?”

	% Respondents					
	SBEM	IES	Tas	Carbon Checker	Hevacomp	All Tools
Very Good	17%	11%	0%	0%	0%	11%
Good	45%	26%	38%	100%	67%	40%
Satisfactory	28%	41%	50%	0%	33%	35%
Unsatisfactory	10%	22%	13%	0%	0%	14%

### 6.3.6.2-Participation in Certification Programs

Table 6.20 shows that over 40% of SBEM, Hevacomp and CarbonChecker users were certified through the BRE Competent Persons Scheme (CPS). Similarly, 40% of IES and Tas users were certified through the CIBSE Low Carbon Consultant Program (LCC). However, over half of all respondents had not participated in any certification program. As discussed in 4.5.3, at the time the surveys were carried out, certification was (and remains) non-mandatory and therefore bears no legal implications.

Table 6.20: Responses to “Which of the following certification programs have you participated in?”

	% Respondents				
	SBEM	IES	Tas	Carbon Checker	Hevacomp
<b>None</b>	36%	48%	38%	50%	29%
<b>BRE CPS</b>	42%	6%	13%	50%	43%
<b>CIBSE LCC</b>	21%	39%	38%	0%	29%
<b>Other*</b>	0%	6%	13%	0%	0%

\*Note: Some respondents did not mention the alternative training denoted by ‘other’. However, in most cases it was used to also refer to on-going accreditation.

## 6.4- Discussion of Survey Findings

The comparative analysis of survey results outlines some emergent patterns with regard to the participants, tools and the methodology that occurred over the period since the (then new) regulations were introduced. The most significant observations that can be made are:

- There was an observed increased specialisation in the occupation of those who undertook the implementation of Part L2A calculations and with regard to the organisations where they worked. In general, the trend moved away from architectural design to more specialised technical functions such as building services engineering.
- It was expected that this increased specialisation would increase the demand for certified professionals with specialised simulation skills; however the results of the second survey show limited growth in the uptake of formal training and formal certification programs.
- With regard to energy compliance demonstration, the accreditation of a wider variety of tools did not greatly affect the distribution of tool use, or improve their quality. Several major issues experienced in using the tools that were reported in the first survey were not resolved and reported again in the second survey.
- A positive aspect that was observed was the increased use of tools for purposes beyond legislative compliance with the aim of improving the energy performance of buildings.
- Respondents’ assessment of the NCM as a methodology improved from ‘unsatisfactory’ in its initial stage of implementation to ‘satisfactory’ in the second survey and a relationship between user rating of the efficiency of the methodology and the tool used was observed.

**Chapter Summary:**

- In the context of longitudinal studies, surveys can be designed and implemented to gather data at multiple points over the period of research to investigate changes in the unit of analysis.
- The analysis of primary data obtained via a two-stage industry survey undertaken at key stages during the implementation of the legislative amendments, allowed the collection of time-relevant information.
- A multistage cluster sampling method was used for participant recruitment. While this method is not as probabilistic as true random sampling, it is still considered effective since it builds on multiple randomisations that allow the comprehensive and efficient investigation of large target populations.
- A quantitative descriptive approach was employed to analyse survey data that mainly consisted of categorical variables. Free text feedback was first coded and analysed in the same manner.
- To explore the existence of significant relationships between variables, relevant guidelines for selecting appropriate measures of association were followed; this involved the implementation of Chi-Square tests and the cross-tabulation of data.
- Results outline emergent patterns, highlights of which include:
  - An observed increase in technical specialisation for both organisational activity and participant occupation;
  - A lack of uptake of formal training and certification
  - The low overall assessment of the NCM as a methodology
  - A significant relationship between user rating of the efficiency of the methodology and the BEPP tool that was used to implement it

## Chapter 7: Industry In-Depth Interviews- Analysis of Application Dynamics

Following the implementation of the longitudinal survey, an in-depth industry interview study with key actors involved in implementing Part L2A compliance simulation and calculations was undertaken. The following presents an overview of the methodology used and an analysis of the descriptive qualitative data that was gathered. The perception of industry professionals on the various aspects involved in the practical implementation and enforcement of the methodology is described and the aspects regarding the practical use of accredited tools, the varying dynamics of the application of the NCM, its integration and the possible influence on the design process are highlighted. Feedback regarding priorities and suggested improvements for future Part L2A revisions is also discussed.

### 7.1-Introduction: Interviews as a Research Instrument

In the context of this study, interviews were carried out with the two groups of professionals (application/validation) involved in the decision-making process associated with the Part L2A compliance process (Figure 7.1). These groups are considered *Key Informants*, who by definition are individuals who as a result of their knowledge, experience and specialist skills have access to valuable information that provides insights about the function that is being interrogated (World Bank 2008; Daskalova 2008). The objectives of each group of interviews are highlighted in Table 7.1.

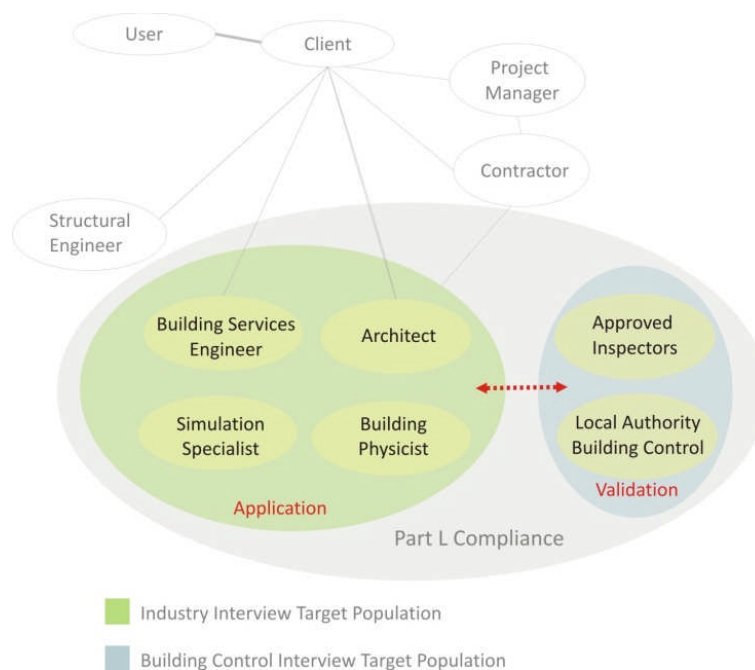


Figure 7.1: Key actors and the definition of the interview target population

Table 7.1: Study objectives

<b>Core Objectives</b>	<ul style="list-style-type: none"> <li>• Determine roles of key actors in the process and their relationship with other responsible parties</li> <li>• Acquire feedback regarding practical and legislative improvements for future revisions of Part L2A</li> </ul>	
<b>Specific Objectives</b>	<b>Industry Interviews</b>	<b>Building Control Interviews</b>
	<b>Investigation of:</b> <ul style="list-style-type: none"> <li>• The practical use of Part L2A accredited tools</li> </ul> <b>Determination of:</b> <ul style="list-style-type: none"> <li>• The varying dynamics of the application of Part L2A calculations</li> <li>• Possible influences on the design process.</li> <li>• Difficulties or challenges in implementation</li> <li>• The general effect of user-influenced input parameters and variability of results</li> </ul>	<b>Investigation of:</b> <ul style="list-style-type: none"> <li>• The enforcement of Part L2A procedures</li> </ul> <b>Determination of:</b> <ul style="list-style-type: none"> <li>• Priority of energy efficiency standards</li> <li>• Knowledge/consistency in interpreting Part L2A requirements</li> <li>• Validity and quality control measures</li> <li>• Difficulties or challenges in dissemination &amp; enforcement</li> </ul>

## 7.2-Study Methodology: Interview Design, Procedures and Implementation

As part of a mixed-method research methodology (Figure 7.2), the interviews were based on a standardised open-ended approach (Tashakkori & Teddlie 2003). The specific design, procedures and implementation approach is described below.

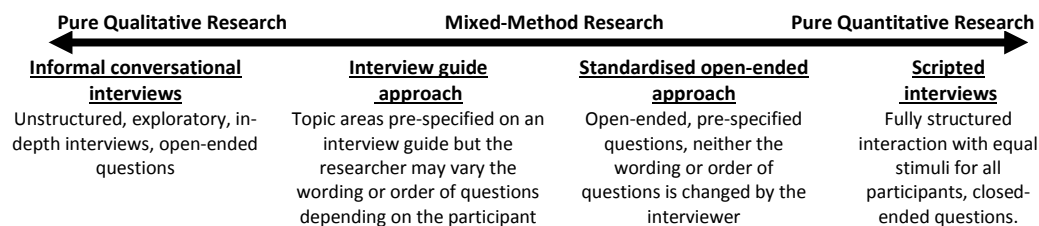


Figure 7.2: Types of research interviews  
Source: Tashakkori & Teddlie 2003

### 7.2.1-Interview Question Types and Structure

In concurrence with relevant guidelines outlined by King (1994), the framework for each of the interviews is structured into two parts; an introductory section followed by a sectioned question set. For each of the sections of the question set, the implementation structure was selected to best address a specific objective defined as a 'key topic'. The combination of both approaches maintains the thematic focus in the interview, while allowing a degree of freedom and adaptability in obtaining the information from the interviewee.

In designing the interview, the question set 'the interview schedule' combines both closed-ended and open-ended questions. The use of predominantly closed ended questions to further define the structured approach was adopted in the first portion of the both interview sets. This familiarises the participants with the focus of the research and produce clearly defined and standardised responses for comparative analysis. The use of open-ended questions in the second semi-structured portion of the interviews allows participants to contribute their opinions and elaborate on their personal experiences in applying and enforcing the methodology involved with Part L2A compliance demonstration. The full schedules for each of the interviews are listed in Appendix C.

In addition to an introductory section, each of the interviews was structured into two distinct sections, which can be described as follows:

#### **i-Industry Interviews**

- **Part One-Tool:** Since this aimed to collect information from different respondents that was predominantly used for comparative analysis, a structured approach adopting the tradition of 'interview data-as-resource' (Seale 2004) was used. This involved the use of a set of standardised questions, the responses to which tend to fit into predetermined categories that facilitate comparison between them (Arthur & Nazaroo 2003).
- **Part Two- Process:** This section aimed to explore emergent themes by probing interviewees for novel information and therefore utilised a semi-structured approach. This portion of the interview adopted the tradition of 'interview data-as-topic' (Seale 2004), where the interview itself is an object of investigation and meanings are subjectively 'constructed', not objectively 'found'. Although a set of 'guide questions' was included to maintain the general structure of the responses, the elimination of non-relevant questions and the inclusion of questions formulated during the interview to follow up leads that emerged was allowed.

#### **ii-Building Control Interviews**

For the building control interviews, the previous pattern repeats itself, however the question set adopted the tradition of 'interview data-as-topic' throughout:

- **Part One-Methodology:** This section explored the Part L2A methodology from the perspective of building control through the use of a semi-structured/ 'interview data-as-topic' approach. Information regarding the respondents training, specific degree of knowledge of the procedures and its perceived effectiveness
- **Part Two-Application:** This section aimed to explore themes such as 'process', 'quality control' and 'issues' by gauging respondent attitudes. Here, the semi-structured/ 'interview data-as-topic' approach used in the previous section was maintained. A set of guide questions was again used to preserve the general structure of the responses. Non-relevant questions were eliminated and questions formulated during the interview to follow up leads were included.

### **7.2.2-Sampling Strategy and Methodology**

Various sampling strategies can be employed in qualitative research, and it is generally recognised that a well-defined sampling strategy with a robust framework is an essential component in ensuring that a study provides robust results (Wilmot 2005; Wilmot 2005a). Due to the nature of the research, to allow the generalisation of the findings of the interviews and applicability of the inferences to the population as a whole, a 'representative' group (of the

respective population) must be studied. In considering the required characteristics of this representative group, it was determined that individuals interviewed had to be considered *Key Informants* (World Bank 2008; Daskalova 2008).

To ensure that this would be the case, a non-random purposive sampling strategy was used to determine this representative group (Tashakkori & Teddlie 1998). This methodology involves the use of the researcher's knowledge in determining and applying selection criteria determined to ensure the suitability of participants for the specific purposes of the research (Trochim 2006). Due to the specific characteristics of the sample group, this strategy is also referred to judgement or expert sampling (Trochim & Donnelly 2006).

Accordingly, within the context of this study two main categories of Key Informants were defined to represent the main functions involved with the Part L2A process. Potential interview participants from each group from various organisations were contacted via the modes of contact outlined in Table 7.2:

#### **i-Implementation: Industry Professionals/Practitioners**

To incorporate a wide scope of perspectives, the defined selection criteria aimed to represent a range of roles and professional backgrounds. This criteria was applied to a list of potential participants compiled from survey respondents who expressed interest in further involvement (the accessible population), in addition to personal contacts made at later phases of the research. Due to the non-mandatory status of accreditation and the relatively low number of individuals who had been accredited under the certification schemes available at the time of these interviews, accreditation was not considered as a pre-requisite for inclusion.

#### **ii-Enforcement: Building Control**

The selection strategy was implemented through the application of criteria to address both public building control (Local Authority Building Control-LABC) and private sector building control (Association of Consultant Approved Inspectors -ACAI). Unlike the industry interviews, no previous information was available with regard to potential participants. Consequently, the participant list was compiled via contact sources such as membership lists from relevant local authorities and professional and trade organisations.

Table 7.2: Methods adopted for participant contact

Interview Type	Target Group	Contact type	Organisation/Group
<b>Industry Interviews</b>	Industry Professionals	Personal/ Group Email	RIBA,BSGS-EDE, CIBSE
<b>Building Control</b>	Approved Inspectors (AIs)	Personal/Group Email	CIC,ACAI
<b>Interviews</b>	Local Authority Building Control (LABCs)	Personal/Group Email	CIC, Local Authorities, LABC



### 7.2.3-Selection Bias, Sample Size and Validity of Results

The use of a purposive sampling strategy allows the study to reflect the nature of the research subject, where participants with specialist skills, expertise and experience are required to answer the questions. This approach helps to ensure that the quality of the information that is collected and the subsequent conclusions that are made is maintained (Daskalova 2008).

However, several issues arise with the use of this strategy. Firstly, the selection of the participant sample in purposive sampling is significantly reliant on subjective researcher judgment (Guarte & Barrios 2006). Furthermore, since the method is in essence non-random, selection bias is to a certain extent-unavoidable (Guarte & Barrios 2006). It is therefore important to recognise that this may impact the establishment of informant impartiality and subsequently, the internal validity of findings (World Bank 2008).

Through the use of a defined set of selection criteria, a representative sample offering varied perspectives from this specialised group can be included (Camargo 2008) and the sample consequently becomes valid over the realm it represents (Tongco 2007). In this case, results are therefore more likely to be statistically and analytically generalisable to the (accessible) population, enabling the extrapolation and transferability of results (Dattalo 2008; Kvale 2007; Tongco 2007; Tashakkori & Teddlie 1998).

With regard to the determination of sample size, the two key features associated with employing a purposive sampling strategy with *Key Informants* are:

- No prerequisite sample size is defined (Strauss & Corbin 1998).
- Sample size is of secondary importance to the criteria used to select participants (Wilmot 2005). This is contingent on that the participants are considered to be representative of the different perspectives regarding the phenomenon and the information required is obtained in the study (Camargo 2008; Bernard 2005).

As guidance for this research, several studies were used as comparative cases to aid in the confirmation of the validity and sufficiency of the sample size for the purposes for which the research was undertaken. These were:

- For initial guidance, a study conducted by Guest et al. (2006) was considered. This work employed the concept of data saturation as a criterion by which to justify adequate purposive sample sizes in qualitative inquiry. This study found that data saturation had for the most part been achieved after the analysis of only 12 interviews from a relatively homogeneous group; this therefore was considered to be the minimum number of interviews that would be required.

- Creswell (2006) recommends that between 20 to 30 interviews be carried out to achieve the high level of detail required in the development of a theoretical model.
- A review of similar interview-based studies in the field provided guidelines as to the number of interviews that would be acceptable (Hopfe et al. 2006; Pegg 2007; Donn 1997).

In this research, a total 25 interviews were carried out with 28 individuals (Table 7.3). This number exceeds that suggested by Guest et al. (2006) for saturation, is within the defined 20-30 interview range and is comparable to the number of interviews carried out in the aforementioned studies.

Table 7.3: Interview participants and number of interviews

Interview Type	Interview Group	No. of Interviews	No. of Participants
Industry Interviews	Industry Professionals	15	16
Building Control Interviews	Approved Inspectors (AI) Local Authority Building Control (LABC)	5 5	6 6

#### 7.2.4-Interview Recording and Transcription

The interviews were recorded using a digital voice recorder. The audio file for each interview was transferred onto a computer for storage and archive generation. In accordance with the previously mentioned ethical practice and data protection issues discussed in section 5.5, participants' permission to record the interviews was sought in the interview set-up stage.

Transcripts are not in themselves copies of the conversation, but are considered to be decontextualised conversations with interpretive constructions that provide useful tools for a given purpose (Kvale 2007). Together with text from sources such as field notes, transcripts represent the most common form of qualitative data used in analysis (Gibbs 2007).

Gibbs (2007, p.13.) describes the act of transcription as "a change of medium that therefore necessarily involves a transformation of data". This process inevitably introduces the issues of accuracy, fidelity and interpretation. The process of transcribing interviews from oral to written mode structures the interview conversation into a form amenable to closer analysis, and can in itself be considered an initial analysis of the data (Rapley 2007; Kvale 2007). Gibbs (2007) describes a scale of varying degrees by which audio recordings are captured.

In this study, the 'verbatim' level of interview transcription was deemed appropriate for the purposes of the study. This level provides an accurate record of the conversation that can easily and appropriately be coded for analysis. To ensure consistency, the audio recordings were transcribed by the researcher according to the transcription conventions outlined by Gibbs (2007). The full interview transcripts from this study are included in Appendix D.

### 7.3-Data Analysis Methodology

A cross-case analysis method (Weisberg et al. 1996) was used for the interpretation of interview responses given by both groups. Due to the nature of the study and the novelty of the information that was gathered, a grounded theory approach was used for development of both the analysis framework and the coding approach.

#### 7.3.1-The Cross-Case Analysis Approach

Cross-case analysis allows the deepening of understanding and explanation, where the multiple cases highlight the specific conditions under which a finding occurs and also form more general categories of how those conditions may be related (Miles & Huberman 1994). Although the goal of generalisation has been argued to be inappropriate for qualitative studies (Denzin 1983; Guba & Lincoln 1981), multi-case designs that have been conducted with the aim of facilitating cross-case analysis enhance the generalisability of results and thus, the relevance and applicability of findings to similar settings (Miles & Huberman 1994).

Within this framework, the interview interpretation incorporated content and meaning analysis techniques to analyse the text at the individual interview level. To analyse the interviews as a whole, a cross-case data analysis method that adopted the mixed-approach recommended by Miles & Huberman (1994) was used. This approach combines the following strategies:

- A *variable-oriented* strategy to outline themes that cut across cases
- A *case-oriented* strategy, which outlines the pattern observed within a case and investigates if the pattern applies across other cases.

The data produced from the structured closed-ended questions that were predominantly used in the first section of the industry interviews, were utilised to systematically measure certain factors for comparative analysis between interview participants and with earlier findings from the survey stage of the research (Burke Johnson & Onwuegbuzie 2004).

#### 7.3.2-Implementation of the Analysis Strategy

The following describes the analysis implementation strategy that was adopted for the industry interviews. After the consideration of factors such as the type of study, the type of data, and the anticipated type of analysis (Weitzman 2000) the process that was developed for the implementation of the data analysis strategy can be described as follows:

##### 7.3.2.1- Computer Assisted Qualitative Data Analysis Software (CAQDAS)

Computer Assisted Qualitative Data Analysis Software (CAQDAS) was primarily developed for the purpose of creating efficient modes of qualitative data analysis (Davis & Meyer 2009; Fielding & Lee 1998) and to support the implementation of analytical procedures that may

otherwise be considered impractical (Mangabeira et al. 2004). Its use therefore allows for a more rapid and rigorous qualitative data analysis process (Rambaree 2007). Limitations associated with the use of CAQDAS include computer literacy, program complexity and the time required for training as compared to managing the data by hand (Fielding & Lee 1998; Mangabeira et al. 2004; Weitzman 2000).

After the consideration of the various software packages available for this purpose QSR Nvivo 7 software (QSR 2010) was selected due to its flexible coding capabilities which allow the categorisation of simple codes into more encompassing themes (Davis & Meyer 2009).

### **7.3.2.2-Data Coding and Categorisation Method**

Coding is a fundamental analytic process in qualitative analysis (Gibbs 2007) that can be defined as “the process of breaking down, examining, comparing, conceptualising and categorising data” (Strauss & Corbin 1998, p.61). The activity of categorisation reduces the meaning of long portions of texts into simple categories, thus providing an overview of a large number of transcripts, and facilitating comparisons and hypothesis testing.

Traditionally, coding has long been a key feature of CAQDAS analysis of interviews (Weitzman & Miles 1995) and involves attaching one or more keywords to a text segment in order to permit later identification of a statement (Kvale 2004; Gibbs 2007). The coding of a text’s ‘meaning’ into categories makes it possible to quantify how often specific themes are addressed in the text. The frequency of the occurrence of specific themes can then be compared and correlated with other measures (Kvale 2004).

The analytical and organisational functions of coding in the context of NVIVO have been discussed by Bazeley and Richards (2000). For this study, since QSR NVIVO 7 allowed for the categorisation of simple codes into more encompassing themes, rather than developing categories in advance, categorisation was undertaken ad hoc based on a grounded theory approach as described by Bringer et al. (2006). This approach was facilitated by the fact that rich descriptions of the specific phenomena to be coded or categorised (which are integral to this analysis approach) were obtained during the interview process (Kvale 2004).

The coding and categorisation steps followed in this analysis can be summarised as:

1. The first stage of analysis entailed analysing two random interview transcripts using a data-driven open coding approach to dissect the data into discrete parts using the ‘free node’ function, where nodes are representative of categories.
2. The nodes were applied to the all interview transcripts. Since all interviews followed the same semi-structured format, this facilitated the application of this information across all interviews.

3. The free nodes data was examined to outline any similarities and differences.
4. Finally, the nodes were refined and conceptually similar nodes were grouped together to form organised categories created with the assistance of the 'tree node' option (Davis & Meyer 2009) and applied to all transcripts.

Accordingly, a number of emergent themes were defined to coincide with the major areas of questions. The detailed analysis node structure on which the categories were based is detailed in the Appendix E. The broad areas of the themes that were subsequently defined are listed below in Table 7.4.

Table 7.4: Main interview themes

Industry Interviews	Building Control Interviews
<ul style="list-style-type: none"> <li>• Project applicability range for Part L2A.</li> <li>• Integration of regulatory compliance &amp; sustainable design.</li> <li>• Compliance process implementation models.</li> <li>• &amp;effective methodology implementation practices.</li> <li>• Roles &amp;responsibilities of key stakeholders.</li> <li>• Tool competencies &amp;knowledge.</li> <li>• Input parameter management &amp; the significance of effective quality control measures.</li> <li>• Methodology issues &amp; recommendations.</li> </ul>	<ul style="list-style-type: none"> <li>• Project applicability range for Part L2A.</li> <li>• Integration of regulatory compliance &amp; sustainable design.</li> <li>• Enforcement implementation models.</li> <li>• Roles &amp; responsibilities of key stakeholders.</li> <li>• Procedural competencies &amp; knowledge.</li> <li>• Effective Inspection practices.</li> <li>• Methodology issues &amp;recommendations.</li> </ul>

## 7.4-Discussion of Key Findings from In-Depth Interviews

This section discusses the key themes and issues that have arisen from the face-to-face in-depth interviews with both industry professionals and building control bodies. After consultation with an expert in the field of qualitative research and the consideration of the nature and aims of the study, it was decided that the findings of both interview sets be incorporated to a single narrative based on an organisational approach suggested by King (1998).

In this method, the combined narrative is structured around the main themes identified, drawing illustrative examples from each interview set as required. Based on this analysis, the findings are grouped by key topic, within which a number of emergent themes were defined.

Throughout the analysis process, where applicable, data tables summarising participant feedback were compiled to aid in content clarification. The full tables, which provide a useful organisational tool for the evidence on which the findings were drawn, are therefore included in Appendix F and referred to where relevant in the text.

When referring to segments or quotations from specific interview transcripts, the coding system described in Appendix D is applied whereby industry interviews are denoted by the letter *I* (e.g., I01 for the first interview) and building control interviews are denoted by the letters *BI* and the same numbering system is applied.

### 7.4.1-Applicability of the Methodology

The key findings from this section are:

- *Industry professionals reported experience with a wide range of non-domestic sector typologies, typically large, complex buildings.*
- *The core of building control experience, particularly LABCs, does not lie within the new non-domestic sector, but in refurbishments and domestic buildings.*

The range of projects selected for discussion by industry professionals (summarised in Table A-F.1) reflect the wide variation of new-build building types found in the non-domestic sector, to which Part L2A is applicable. The projects were typically large, complex non-domestic buildings with multi-components that were situated at various locations around the country.

Only one of the selected projects described a less typical case involving a large residential house, which fell under the scope of Part L2A due to the fact that its total floor area exceeded 1000m<sup>2</sup>. This project also included the use of innovative design features and renewable energy technologies.

The building control interviews show that there was a significant variation in the project types dealt with by each of the groups interviewed:

- LABCs are generally required to deal with whichever project types that fall within the boundary of their local authorities. Thus, refurbishments and residential buildings that fall under Part L1A constitute the majority of projects dealt with and is where their expertise generally lies (BI01). With regard to the projects discussed in these interviews, the majority of projects that fell under the scope of Part L2A included smaller community buildings (e.g. nursing homes, libraries) and small retail buildings (BI01, BI05). A few higher value projects such as larger commercial developments were discussed. These were selected by LABCs operating in inner city boroughs where projects of this nature are more likely to be located (BI09).
- AIs were more extensively involved with a wider range of comparatively larger non-domestic projects, such as commercial offices, universities, museums and libraries. These projects typically had a higher average project value (BI02, BI04, BI06). The impact of the recent economic climate (BI04) led to AIs taking on more residential projects than they would have in previous years, although in this case they tended to deal with a wider range and more complex domestic buildings such as high-rise residential blocks (BI03, BI06).

### 7.4.2-Drivers and Impacts

The key findings from this section are:

- *The importance of energy legislation had increased over the past few years and was in general expected to continue doing so.*
- *In addition to traditional governmental requirements, drivers for the implementation of energy legislation have expanded to include client and designer led initiatives/agendas.*
- *There was a tendency for Part L to be viewed as a regulatory requirement rather than a sustainability issue, therefore more integration is required between Part L and other sustainability targets.*
- *In response to the introduction of the Part L2A amendments, the majority of industry participants reported the occurrence of various organisational changes.*
- *For building control, familiarity with the enforcement of pre-existing residential procedures had helped establish a foundation for the new regulations. Changes in this capacity focused on measures to meet the increased workload.*

Traditionally, health and safety aspects were considered to be the most important areas covered by the regulations. Energy legislation in general and Part L in particular, had previously been considered “quite low down” (BI07) in terms of priority. The integration of the consideration of environmental performance in legislation had aided in moving energy efficiency from best practice to a legal requirement and over the past few years, the importance of energy legislation had therefore increased and was in general expected to continue to go up the agenda (BI03).

This increased importance was attributed to the increased awareness of climate change issues and the realisation that measures should be taken to decrease CO<sub>2</sub> emissions within the country’s property stock (BI06). Key parties such as the DCLG played an important part in advertising the importance of energy efficiency through educational seminars and training material (BI01, BI08). Consequently, Part L was now considered to be a key aspect alongside traditional health and safety requirements for any project (BI02, BI07). Part L was also considered integral in ensuring the health and safety aspects of the regulations, since the requirement for the minimisation of overheating was included under it (BI04, BI05).

In terms of applicable environmental and energy legislation, all projects discussed were subject to the requirements of Part L2A. In addition, several had additional sustainability targets driven by such factors as:

- Planning requirements requiring further CO<sub>2</sub> emissions reductions imposed by local authorities or city/town councils.
- An enhanced sustainability agenda led by either the client (I15) or designer (I03). These projects encompassed such themes as 'pragmatic sustainable design' and were in some instances required to achieve a self-imposed BREEAM rating.
- A client led economic-based imperative, where achieving CO<sub>2</sub> emissions reductions through energy efficiency measures was increasingly associated with (positive) financial gain (BI03).

Although the consideration of a wider scope of sustainability targets is in itself positive, it must be noted that in this context there was a tendency for Part L to be viewed as a regulatory requirement rather than a sustainability issue. This indicates a need for further efforts to promote the integration of Part L2A requirements with the various sustainability targets mentioned.

In terms of its impact on working practices, industry participant responses indicated that Part L2A was considered to be enough of a divergence from previous practices to warrant the introduction of changes to support its application within their organisation. Consequently, a number of measures had been undertaken to achieve this. These included the initiation of training programs to familiarise employees with the regulations and, in particular, the use of BEPP tools for its application. In addition, it was reported that measures were undertaken to meet or deal with user accreditation requirements that were perceived to be mandatory by some interview participants.

With regard to BCBs, some participants (e.g. BI02) stated that no significant changes had occurred within their organisation with the advent of 2006 amendments. The pre-existing residential procedures in place since the 1990s were cited as a factor that had somewhat helped to establish a foundation for the new regulations (BI05). However, the majority of those interviewed stated that some changes such as increased staff training and the appointment of specialised services consultants to help with related duties had occurred (BI02).

Despite initial government assessments projecting that the introduction of Part L 2006 would not increase the work burden of BCBs, prior to the enforcement of the regulations in April 2006 an influx of projects submitted to BCBs was observed by participants. This was thought to be primarily driven by the clients desire to avoid dealing with the proposed changes (BI06, BI09). Consequently, workloads had initially increased (BI06, BI08, and BI09) to both deal with this influx and eventually as a result of the effort required to familiarise various parties with the requirements of the new system (BI07). Further workload increases that were reported at later stages of implementation of Part L 2006 were fuelled by a conscious decision on the BCBs part to increase the scope of their involvement and take on more work (BI08).



### 7.4.3-The Dynamics of the Application of Part L2A Compliance: Organisational and Implementation Models

The key findings from this section are:

- *Within the context of a generally well-defined organisational group structure, the format, scope and function of roles in the direct implementation of Part L2A varied greatly.*
- *Successful models of implementation that provided effective compliance process application included the use of a compliance pre-check 'indicative study'. Here, the compliance tools are used in a design capacity to facilitate the assessment of the feasibility of options.*
- *A considerable majority of participants reported that compliance checking contributed to informing the decision-making process.*
- *Early involvement during the initial design stages was preferred. This was generally viewed to be essential in facilitating discussion with the design team and incorporating recommendations through iterative design.*
- *Three main factors influence the selection of the optimal implementation stage of the Part L2A compliance process: project size, definitiveness of the design and planning requirements.*
- *For the majority of projects discussed the Part L2A compliance process was mainly initiated at Stages C-D of the RIBA Work Plan 2007.*

#### 7.4.3.1-Stakeholder Roles and Dynamics

Within the context of the organisational structure, Part L2A related functions were in many cases viewed as a specialist service (I07). Consequently, whereas the role of each group of stakeholders (summarised in Table A-F.2) involved in the design process was well defined in terms of function and responsibilities (i.e. architects for the provision of design drawings, MEP for HVAC systems design), the functions related to the actual implementation of Part L2A tended to be less defined.

The group function the implementation of Part L2A was included under often varied according to available company resources and the organisation's area of expertise. Table A-F.3 shows the format, scope and function of roles in the direct implementation of Part L2A. Some of the more common examples of this included the integration of the Part L2A functions under the umbrella of general building services design. A more defined approach where a specialised 'sustainability and building analysis group' was responsible for the calculations also existed (I01). Direct appointment to the client was generally considered more beneficial since this arrangement facilitated more direct consultation with the architect and other project members (I05).

### 7.4.3.2-Models of Implementation

A successful model of implementation that was adopted (I04, I05, I12, I13) was the use of compliance pre-check, which was referred to by various participants as an 'indicative study' or 'sensitivity study', here the accredited BEPP tools were used in a design capacity (Figure 7.3). This process generally involved the following steps:

1. The building model is created and an initial tool run is implemented.
2. The potential CO<sub>2</sub> savings from the building fabric, HVAC systems (e.g. heating, cooling, fans, pumps and controls) and lighting are then examined to identify which can yield the most savings (I06).
3. Various energy efficiency options such as different glazing specifications, increasing insulation, increasing air tightness, upgrading the efficiency of heating/cooling plant, ventilation and lighting systems are considered to see the relative impact of each.
4. Costs associated with the various options are estimated.
5. The design team discusses the feasibility of each option and selects those that incur the least economic impact and best fit the aesthetics of the project (I04).
6. The suggested improvements are then layered one over the other, to produce one of the viable routes to compliance (I05).

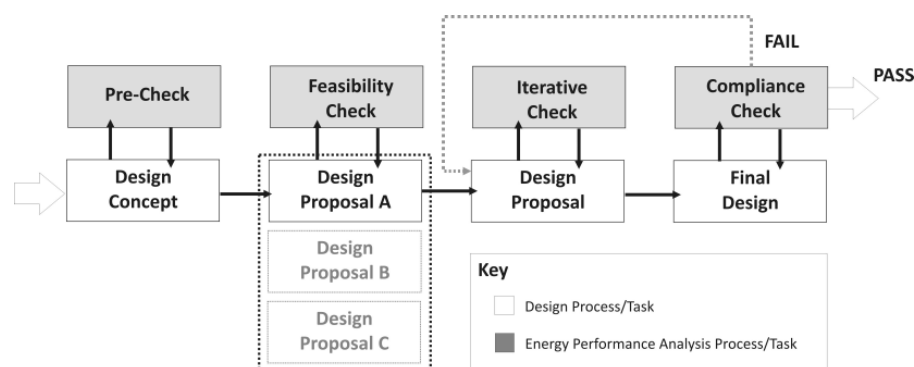


Figure 7.3: Implementation models: The indicative study

This approach requires the availability of a sufficient amount of building data early on in the design process. The required data was sourced from a number of parties with varying degrees of involvement in the compliance process, the general break down of the most important types of information and sources is summarised in Table A-F.4.

The application of these models results in a more integrated approach where compliance checking can in some ways usefully inform the design process. Other participants who had not utilised a similar approach reported that compliance checking was undertaken as an independent exercise that in no way contributed to the decision-making process, or could not confirm if it did.

#### **7.4.3.3-Implementation Tools: The Use of BEPP Software**

DSM tools were predominantly used to undertake the Part L2A calculation and associated analysis tasks. This included the modelling of the effect of introducing renewable technologies such as GSHPs, which the participants felt could not be adequately modelled using SBEM. In addition, DSMs were also used to perform further analyses such as shading calculations, thermal modelling and building services design. By comparison, the use of FI-SBEMs was largely limited. In cases when SBEM was utilised for the Part L2A calculation, DSMs were used in conjunction to undertake the previously mentioned analyses that were considered to be beyond the technical scope of SBEM as a calculation tool.

A number of factors that shed light on the decision-making process that users undertake when selecting the tool were stated. The most important of those mentioned by participants are summarised in Table A-F.5 and included such aspects as tool availability, capability and financial factors.

#### **7.4.3.4-Implementation Timescales and Durations**

In many of the cases described by interview participants, the initial Part L2A compliance run did not result in the proposed design achieving a 'pass' outcome; this was more frequently observed when the involvement of the participant and the implementation of the compliance process was only considered in the later design stages. This suggests that early involvement, and the consideration of Part L2A compliance calculations at the optimal design stage, is integral in achieving compliance since it facilitates discussion with the design team and allows the incorporation of recommendations through iterative design (I12).

In defining the optimal stage of implementation of the Part L2A compliance process, the majority of participants expressed a preference for early involvement, so that issues that arise can be found out earlier and brought to the attention of relevant parties (I08). However, early implementation of the actual calculations was not necessarily viewed as always being beneficial.

The three main factors that influenced the selection of the optimal implementation stage are:

- **Size of project:** On smaller projects a later implementation stage will have minimal impact. However, with the larger and more complex projects, it is more significant that Part L2A tasks are addressed early on.
- **Definitiveness of the design:** How much the project will change was cited as another factor in determining implementation stage preference. If a design was likely to change significantly, had not been finalised or available information was insufficient (I09), it was difficult to establish if the final design would eventually pass Part L2A requirements (I01). It

was therefore considered more productive if Part L2A calculations are delayed until the design was more 'solid' (I09).

- **Planning requirements:** In some cases, it was mentioned that the existence of additional planning requirements such as those enforced by the Greater London Authority (GLA), had necessitated that the implementation of the Part L2A compliance calculations was carried out early on (I14).

For the majority of projects discussed, the Part L2A calculation work was mainly initiated at Stages C-D of the RIBA Work Plan 2007 (Figure 7.4). For a few cases, calculations were again revised at later stages (E-F). When circumstances resulted in later involvement in Stages E or F (and in one case even Stage K), some participants reported that this often resulted in the occurrence of problems in all but relatively small and simple buildings (I08).

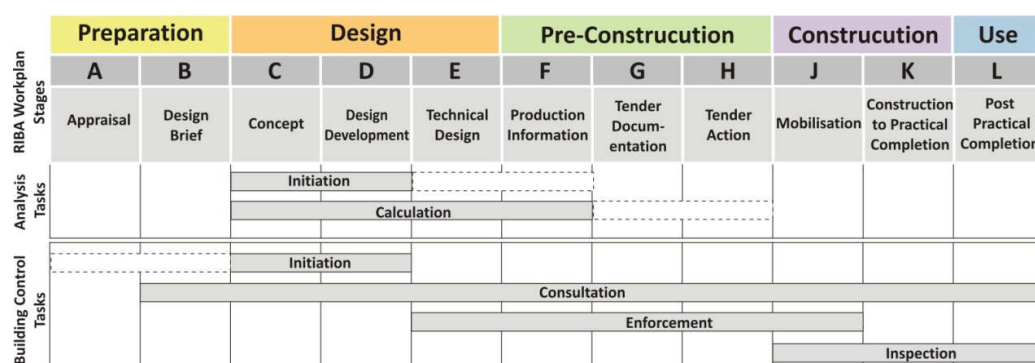


Figure 7.4: Implementation timescales for analysis and building control tasks  
Source: Adapted from RIBA 2008

The actual time that was taken for the implementation of the compliance process usually spanned over several weeks. Typically, the time taken to model the building and run the Part L2A calculation approximately lasted between 40 hours (~1 week) for a typical building, reaching up to 100 hours (~2.5 weeks) for more complicated buildings.

In cases where the time allocated for the process was exceeded, this was usually a consequence of unforeseen problems such as restricted information flow arising from communication difficulties between parties, the lack of information, design changes or the underestimation of the complexity of the buildings.

#### 7.4.4-The Dynamics of Enforcing Part L2A Compliance: Submission, Inspection and Approval Models

The key findings from this section are:

- *To accommodate perceived accreditation requirements, a number of non-accredited individuals would undertake the Part L2A calculations; however this work would then be submitted by an accredited individual.*
- *The scope of the role, tasks and extent of involvement of BCBs is typically influenced both by project type and by the design team.*
- *Although prevented from giving explicit design guidance, within the context of their role, BCBs can play an important role in influencing the design and project compliance.*

##### 7.4.4.1-Submission Routes

At the time when each of the interviews was undertaken, most projects selected by participants for discussion had either passed the requirements of building control or had been submitted with approval pending. Submission of the work tended to follow either a direct route to building control (I03, I04, I08) or via a third party such as the architect or client (I02). A model that was often adopted to accommodate perceived accreditation requirements while avoiding the time-consuming and costly process involved was described by a number of participants (e.g. I06). In this system, a 'base group' comprised of a number of non-accredited individuals within the company would undertake the Part L2A calculations, however this work would then be submitted by an alternate individual employed at the company who was accredited under either the BRE CPS or CIBSE LCC scheme.

##### 7.4.4.2-Building Control Bodies: Roles and Functions

Building control professionals felt that the methodology effectively facilitated their role by using a clear method of compliance demonstration with pass/fail criteria (BI06, BI10). The methodology had also eliminated the need for time consuming tasks such as checking envelope elements (BI01, BI02).

In the case of the formal submission of Part L2A documents for all but four of the projects discussed, some degree of involvement and interaction with building control bodies (especially AIs) was considered standard practice. The variable scope of the role and consequently the tasks associated with both types of BCBs (public sector LABCs and private sector AIs) are summarised in Table A-F.6.

The extent of involvement of BCBs is typically influenced both by the project type and by the design team. At the lower end of the project value scale (where LABCs are more likely to be involved) reliance on the relevant BCBs to provide information and extensive guidance was higher. With larger developments, where AIs are usually brought on board, specialist consultants are usually appointed to address the more technical aspects related to energy efficiency.

By law, BCBs in general are prevented from giving explicit design guidance (BI02, BI03) since it conflicts with the main role of building control. However, within the scope of their role, BCB participants outlined a number of areas where they often play an integral role in providing some degree of feedback, which can - as a consequence - significantly affect the design development process. These include:

- Informing the client and the consultant of the requirements of Part L (BI03, BI04).
- Aiding project teams in integrating building regulations and planning requirements.
- Providing compliance options (BI06), advice on the best compliance procedures and how to apply them (BI01, BI02, BI06, BI09, BI10).
- Providing advice on what parameters to include in the (SBEM) compliance calculation (BI07).
- Solving related issues that pertain to planning law (BI01).

The main point of contact with BCBs on a project varied throughout the design and construction process. This role is usually taken on by the architect (BI05, BI07, BI10) or developer (BI10) early on and architect or consultant at later stages of the design process (BI10). Other points of contact include the client (BI03, BI08, BI10) and project managers, who can play a significant role in the early appointment of BCBs at an early stage due to their understanding of the benefits of 'freezing' the design early on (BI02, BI06).

#### **7.4.4.3-Enforcement Timescales and Durations**

Interaction with BCBs was undertaken in both formal and informal settings through methods such as scheduled meetings and inviting building control to attend design meetings to less interaction-intensive methods such as letters or telephone calls.

There was a general consensus by both of the groups interviewed that meetings held early on in the design process were preferred since they facilitated easier and more productive interaction between stakeholders (I02, BI10). This was viewed as essential for the safe handover of a project (BI03), since it reduces the occurrence of abortive design practices (BI06). In addition, effective communication can potentially ensure that the guidance provided is both design-effective (BI03) and cost-effective (BI04). For this reason, participants often preferred using AIs to LABCs – citing that AIs could be engaged at earlier project stages.

The stage where the involvement of BCBs is initiated varies (BI07) and is influenced by a number of factors. For example, on smaller projects that involve a design/build contractor, BCBs might not be appointed until later project design stages (BI07), conversely in the case of 'partnering schemes', the involvement of LABCs is far more extensive and usually takes place early on in the design process (BI08).

With reference to the RIBA work plan stages outlined in Figure 7.4, the involvement of BCBs was in some cases initiated as early as Stage A or B (BI03) or even as late as Stage E (Technical Design) (I06, BI10). However, in most cases BCBs were usually taken on board at Stage C or D (BI02, BI04, BI05, and BI06).

Similar to industry participants, the determination of the optimal stage for involvement for BCBs is influenced by several factors, the most significant of which was the availability of adequate design information that enabled BCBs to determine the scope of their function (BI08). Most considered that this to be the case when definitive floor plans and adequate information with regard to systems became available.

Accordingly, most viewed that initial involvement just before or prior to Stage C/D was most beneficial (BI02). Involvement prior to this stage was not preferred, since project information that was expected to be available before this was considered to lack the required clarity and definitiveness (BI05).

#### 7.4.5-Procedural Knowledge and Training Strategies

**The key findings from this section are:**

- *Industry professionals were highly confident with regard to their proficiency and abilities relating to Part L2A. BCB participants stated that they believed they had adequate knowledge of procedure. However, in most cases the information was more focused on outputs and tool knowledge was largely limited.*
- *Adequate knowledge and the attainment of basic skills required to fulfil the requirements of both of these roles was largely attributable to a specialised degree in the field and/or receiving adequate training within the context of the workplace.*
- *Most organisations adopted some form of training strategy to familiarise the staff with the required procedures.*
- *A third of industry participants were not accredited under either available schemes and there was a large degree of confusion with regard to if it was mandatory.*

#### 7.4.5.1-Knowledge and Experience

Industry professionals interviewed were 'extremely' to 'reasonably' confident with regard to their proficiency and abilities relating to Part L2A as highlighted in the following interview statements:

- *"As a company we're very, very experienced in using IES."* (I04-Line 26)
- *"I've passed the accreditation exam for it. But, I mean there's a lot of bugs still in the software, so it's still continuing to learn it all"* (I02-Line 19).

Although many participants had considerable experience in the field (working experience in the construction industry) that reached up to 25 years in some cases, by comparison experience with tool use was much shorter and was for most cases about 2 years. This indicates that many participants' experience with tools coincided with the introduction of the Part L 2006 regulations. This also suggests that the regulations had therefore - to an extent - contributed to the uptake of BEPP tools. Some participant profiles (with regard to educational background and experience) also suggest that they were specifically recruited and trained for purposes related to building energy performance modelling and analysis in general and implementing Part L2A calculations in particular.

With regard to BCBs, participants stated that they believed they had adequate knowledge of Part L2A procedures (BI06, BI03), although in most cases this knowledge was more focused on the interpretation of output documents (i.e. the BRUKL) (BI02, BI03). In general, their knowledge of the input data or calculation procedures was limited to what was considered relevant to demonstrating compliance towards the end of the project (BI03). In areas that were considered to be beyond their field of expertise, the acquisition of the required knowledge involved undertaking background research. This was either carried out by other specialised members of the organisation (BI04) and then disseminated to other employees or the task would be delegated to employees with the relevant knowledge/qualifications (BI08).

Even though a number of BCBs had expansive procedural knowledge and experience, knowledge of particular aspects of the tools used was by comparison largely limited. In some cases, SBEM was confused with the NCM and the two terms were often used interchangeably (BI04). Although all BCB participants were familiar with the concepts of simplified and dynamic modelling, not many had knowledge of the various accredited BEPP tools other than SBEM, which was the most frequently used tool used on projects they were involved in (BI01). However, AIs were more aware of the various tool options, were knowledgeable as to the basic differences between them (BI02, BI06, BI07) and recognised a wide range of instances when their use was more appropriate (BI02).



#### 7.4.5.2-Training Strategies

In general, participants who had more in-depth knowledge had usually earned a specialised (higher) degree (e.g. MSc.) in the field (BI05). For both groups interviewed, adequate knowledge of tools was largely attributable to receiving adequate training in the context of the workplace. This was either provided by software vendors or through accreditation-based training that was undertaken in the lead up to certification exams (BI07).

In anticipation of the changes associated with the Part L 2006 regulations, most organisations adopted some form of training strategy to familiarise the staff with the procedures. The various forms of training can be summarised as follows:

- **Training Models:** With regard to which employees within the organisations received training, the following two (separate) models were defined:
  - a. **All staff:** Training for all individuals within the organisation was provided.
  - b. **Targeted training:** Only specific key or representative employees (BI10) (such as specially appointed services consultants) received instruction, usually via an external training course (BI02, BI08). In turn, these individuals were expected to disseminate the information within the organisation. Individuals who had not received any training were also supported by internal research staff (BI04).
- **Training Methods:** Most participants interviewed had undertaken some sort of training within the framework of either of the following strategies:
  - a. **External training:** This included very basic methods such as running through training manuals and other material. For example, multimedia training CDs were produced by organisations such as the Royal Institute of Chartered Surveyors (RICS) (BI02). More extensive methods such as introductory seminars (BI05, BI10) and short courses provided by professional organisations such as the Association of Building Engineers (ABE) (BI01, BI06), the RICS (BI01, BI03, BI06), CIBSE (BI04), DCLG (BI07) or mid-career colleges (BI02) were also cited.
  - b. **Internal training:** This was either provided by experts from within the organisation or by external agents brought in to provide internal training (BI09). This was often undertaken in the form of CPD seminars (BI02, BI03, BI08) or 'on the job' practical training (BI09).

#### 7.4.5.3-Accreditation Schemes

The ratio of accredited to non-accredited participants was 10:5, indicating that although most participants were accredited under either the CIBSE LCC or BRE CPS scheme (and in some cases under both e.g. I04), a third were not. Additionally, apart from a few participants with extensive experience (I06), there was a large degree of confusion with regard to if Part L2A accreditation

was mandatory. Almost all BCBs believed that the accreditation was a necessary legal requirement (BI01, BI0, BI08). However, it must be noted that this perception that accreditation was mandatory could in theory have been a significant factor in motivating industry professionals to undertake adequate training required to acquire sufficient skill-sets.

#### 7.4.6-Quality Assurance and Results Validity

The key findings from this section are:

- *Lighting and HVAC systems parameters were reported to have the most significant impact on the outcome of compliance demonstration, resulting in an estimated reduction in predicted CO<sub>2</sub> emissions ranging between 5- 50%.*
- *The development of a functional quality assurance (QA) system was cited as important in establishing the validity of the compliance results, and also served for both educational and design review purposes.*
- *QA procedures were employed at various levels both prior to submission and during the submission and enforcement.*
- *Results indicate that the accreditation status of the individual did not affect the quality of the calculation. For non-accredited individuals, competency was determined based on the personal judgement of the BCB or the architect involved.*
- *A degree of inconsistency in understanding and applying the required procedures existed. This is exemplified by the confusion regarding the accreditation of both individuals and methodologies as well as the status of implementation of overheating checks.*

##### 7.4.6.1-Impact of Input Parameters

The significant impact of input parameters on each of the individual projects selected by participants for discussion was highlighted. Table A-F.7 summarises each of the parameters and the reported consequent predicted CO<sub>2</sub> emission reductions for each. Lighting and HVAC systems parameters were reported to have that most significant impact on the outcome of compliance demonstration, resulting in an estimated reduction in predicted CO<sub>2</sub> emissions ranging between 5-50%. Other factors that affected the outcome of calculations can be outlined as:

- **Program defaults:** This was the main reason given for an initial 'fail' outcome of the compliance check (I05, I12). This issue was addressed by altering the default parameters in future runs.
- **System parameters:** This included the reassignment of systems or changing parameters such as specific fan power, efficiencies and ventilation specifications. It was often mentioned that it

was in general more difficult to achieve a 'pass' compliance outcome for a naturally ventilated building than it was for an air-conditioned equivalent (I02).

- Lighting and controls: This was considered by most participants to be the systems related parameter that had the greatest effect on results. Since most tools tended to overestimate lighting loads (I12), this parameter could easily be changed if required (I09).
- Fabric properties: Glazing G-values and material U-Values were considered fundamental for achieving compliance for both Criterion 1 and Criterion 3 (minimisation of overheating).
- Other parameters for special project types: These included altering heating loads in the case of a swimming pool (I12) and changing assumed night-purge inputs in the case of the electrical grid building (I15).

#### **7.4.6.2-Quality Assurance and Control Methods**

Table A-F.8 outlines a number of quality assurance (QA) procedures employed at various levels, both prior to submission and during the submission and enforcement process. The importance of the development of a functional QA system was discussed by many participants (I12), who believed that its absence presented some risk of variability in the results (I04) that could potentially affect the validity of the compliance demonstration process. QA systems were often also employed for educational purposes as well as for design review (I04).

While auditing the actual compliance procedure in its entirety can be time consuming (I14), the QA procedures undertaken often went beyond simply checking output results, to include monitoring the input data used. Models were also compared with similar projects undertaken in the past in what was referred to as a 'reality check'.

With regard to BCBs, systems developed to track compliance over the project lifecycle were viewed as imperative in ensuring its enforcement (BI08, BI10). In addition to checking the BRUKL document, a number of BCBs required the submission of data input sheets detailing information such as U-Values and the solar shading analyses (BI02, BI04, BI06), insulation and air pressure checks (BI03) and commissioned items (BI01, BI02, BI07).

In many cases, BCBs believed that user accreditation was a necessary legal requirement for submission of compliance demonstration documents (BI01, BI06, BI08). For those who were aware that accreditation was not mandatory, the competency of individuals was based on their personal judgement or that of the architect involved (BI04, BI05). This would be undertaken to verify if the right software was used, the correct procedures were followed and to establish the suitability/competency (BI10) of the individual. As a further measure, the submission of the calculation details for review would (on occasion) be requested (BI02).

The majority of BCBs reported that they only accepted compliance demonstration through the accredited methodologies (BI01, BI04) or were unaware of any cases where submissions included the use of alternative methods (BI02, BI03, BI09). For those who did not limit the submission of information to the NCM, other methods such as hand calculations (that had been adequately tried and tested) would be accepted (BI10). In this case, the information provided would be checked to ensure that it complied with the functional requirements of the building regulations and accepted, comments would then be provided on that basis (BI06).

With regard to the minimisation of overheating, some participants mentioned that they had come across various methods to demonstrate that the CIBSE guide requirements for the limitation of solar overheating had been met. This was expected to be the case since no formal procedure had yet been mandated in Part L 2006 for demonstrating this requirement (BI02, BI07). Some confusion existed with regard to the capability of SBEM to perform the required overheating checks (BI05)<sup>13</sup>. In this case, BCBs stated that it would therefore be difficult to justify accepting an output that did not come from SBEM or an approved BEPP tool (BI08).

#### 7.4.7-Issues in Implementation and Enforcement

The key findings from this section are:

- *Increased complexity and specialisation was the main issue affecting the implementation of the methodology.*
- *Participant responses indicated that their assessment of the process was not concerned with the methodology alone, but was significantly influenced by other factors such as the quality and capability of the software that was available to them.*
- *A lack of clarity in application and integration between the multiple energy efficiency targets was reported.*
- *Most BCBs agreed that more stringent enforcement measures were required, but acknowledged that they were both viewed and considered themselves to be overworked and under resourced.*
- *The lack of communication, education, and understanding of the design team, were the main issues that affected the design stage. Designers were, at times, unaware of the need to carry out compliance demonstration and lacked knowledge of the associated information required.*
- *Continual amendments created confusion, further compounded by the use of transitional provisions.*

<sup>13</sup> SBEM did not have this capability at the time. This has been revised in the 2010 amendments and is discussed in section 9.3.2.2

The analysis of responses outlined several areas of concern. The following presents the main issues reported by both groups. These are organised by topic, followed by the key interview statements that best highlight each issue. A more detailed list of issues and supporting statements on which the analysis was based is included in Appendix F-2.

#### **7.4.7.1-The Compliance Methodology**

- *“The recurring issue is the compliance methodology (is), seems to be open to interpretation when you’ve got buildings and systems that don’t really match an existing definition” (I01-Line 127)*
- *“Convoluting, that’s the only word for that”(I09-Line 214)*
- *“it was quite hard to understand. It was a bit of a black box in the sense that we couldn’t see what was going on” (I11-Line 160)*

The majority of industry respondents interviewed stated that the fundamental idea underlying the NCM was in principle useful (I03, I04, I05, I06, I07). The methodology was viewed to have positively contributed to the energy efficiency of buildings since its introduction by concentrating design focus on issues relating to sustainability (I15, I06). Compared to previous iterations of the regulations, the methodology was considered to enable an adequate degree of design flexibility for most common or typical system types (BI05, I05) and had become more effective in terms of allowing more detailed modelling (BI07). However, several major problems associated with the methodology such as complexity, flexibility and transparency were highlighted.

#### **7.4.7.2-Software Tools**

- *The main problem we have is with the software (I02-Line 109)*
- *“(the software is) not perfectly suited to Part L” (I07-Line 142)*
- *“it’s more about the limitations of the program constraining you to have to solve another set of problems in terms of how you actually bring reality into the domain of a piece of software” (I07-Line 114)*
- *“you probably need to spend quite a few years to learn the nuances and the problems with the software and how to get round them”(I04-Line 29)*
- *“checks for software compliance are not stringent enough and they should be more detailed” (I01-Line 135)*

Views regarding satisfaction with the BEPP tool each participant used were equally divided between those who were satisfied and those who were not. However, one of the most important observations that can be noted from participant responses is that many had no or very limited experience beyond the tool that they were using. This meant that they therefore had no basis for comparing its technical capability with what was more generally available at the time. Some examples of this include:

- *"I'm not really aware of any other models and how to use them"* (I08-Line 34).
- *"Based on my fairly limited experience using the other tools, it's hard to say"* (I01-Line 36)
- *"I don't know of anything better, but I can easily imagine a tool that would be"* (I09-Line 40)

#### **7.4.7.3-Enforcement and Inspection Procedures**

- *"I think they need to make the responsibility clear as who's responsible for Part L compliance"* (I03-Line 189)
- *"you get inconsistent application across authority boundaries and within authorities themselves"* (BI05-Line 292)
- *"there should be a legal requirement that an (on-site) inspection should be made. We'd all have to do that work and inspect it"*(BI01-Line 274)
- *"the whole thing is confused because the likes of GLA and planning authorities have involved themselves quite heavily"* (BI05-284)

The implementation of the methodology and consequently the validity of the end report (the BRUKL) is in large part reliant on the correctness of the input data, interpretation of information and the implementation of procedures (BI04, BI06). This emphasises the role of building control in ensuring the success of the compliance process. However, under the current system which involves numerous steps in various areas, BCBs cited that the lack of consistency of approach had made it difficult to correctly enforce the requirements (BI08). In addition, some felt that the methodology itself had in effect limited their opportunity to give on-site feedback.

Although BCBs were both viewed and considered themselves to be overworked and under resourced (I12), most agreed with the view that more stringent enforcement measures were required (BI03).

#### **7.4.7.4-Information**

- *"The reliability of the information, that's the main one. Even manufacturers information isn't always reliable"* (BI05-Line 313)
- *"(the design teams) sometimes aren't aware of the detailed information that's required now to show compliance"* (BI06-Line 181)
- *"The information available at the time (early on) is insufficient, so you could leave yourself go very far down the line without knowing whether you comply or not (because you can't carry out the calculation early)"* (I09-Line 78)

The questionable reliability of the available information, the lack standardisation of input data obtained from various sources (e.g. manufacturers data) and differences in interpreting definitions such as 'high-usage personnel door' or 'display lighting', were highlighted as issues that could potentially affect the validity of input data, and consequently, the results (BI05).

#### 7.4.7.5-Issues with Personnel

- *“the local architects [...] they’re not even aware where the rules have changed”* (BI01-Line 61)
- *“The problem then is quality control of the people producing it and I have no idea how their organisations work and that’s where the error(s) is”* (I012-Line 299)
- *“an internal lack of communication between the designers and the modellers”* (I15-Line 209)

The major issues associated with personnel were closely linked with those affecting information provision and flow. The consequent lack of adequate knowledge concerning both procedures and legislative changes was reported and in cases where several parties were involved, the lack of communication between personnel was viewed as detrimental. The issue of determining the capability of personnel regarding the required skills was considered to be an essential requirement for maintaining the validity of the process that was not always fulfilled.

#### 7.4.8-Future Priorities and Recommendations for Future Revisions

The key areas of priority defined in this section are:

- *Increasing methodology transparency and clarity.*
- *Increasing tool flexibility and the facilitation of more representative HVAC systems modelling.*
- *The introduction of a clear enforcement system and improving enforcement capability.*

With regard to legislative revision procedures, the period of four years<sup>14</sup> between the 2006 and 2010 review was considered to be sufficient to maintain achievable progress (BI01, BI02, BI03, BI04, BI05, BI08, BI10), but participants were also aware that this did not guarantee that the changes were necessarily going to be effective (BI03). While the current lead-in period of six months for regulations to be circulated before they were implemented was considered adequate (BI06, BI02), a further extension to this was viewed to be more beneficial (BI08). Suggestions included that this period be proportionate to the extent and type of changes brought in every review (BI07, BI10).

Since targets regarding building fabric were limited by the physical properties of materials, the main thrust of any future revisions was expected to be based on more technologically advanced systems (BI06). It was felt that adequate periods should be allowed between revisions to allow the manufacturing industry the time to undertake the required research and testing (BI06). This was also the case for software developers, where sufficient time should be provided to allow the development of adequate software which was an issue in the introduction of the 2006 regulations (BI06). The main priorities that participants felt should be addressed in upcoming revisions and suggested recommendations are discussed in the following sections.

<sup>14</sup> This has been revised to three years between upcoming legislative revisions scheduled for 2013 and 2016.

#### **7.4.8.1-The Compliance Methodology**

With regard to the methodology, participants generally mentioned several issues that should be prioritised in upcoming revisions and made recommendations to address them. These included:

- a. *Increasing the clarity and transparency of the methodology:* It was suggested that future revisions should prioritise simplifying and increasing the transparency of the current modelling methodologies (I08, I11, I13). Suggestions included the provision of sufficient guidance and procedural training on the modelling of the range of system types (I05). This would avoid misunderstandings and miscommunication and would encourage the active involvement of architects and developers, who in general rely on consultants to deal with complex legislative procedures (BI04, BI07).
- b. *The introduction an approach that specifically catered for smaller project:* As a complementary measure to the simplification of the main methodology, the development of an even simpler methodology for smaller projects was suggested (BI05, BI10).
- c. *Reassessment of current modelling assumptions and NCM templates:* This was viewed as an essential factor in establishing their validity and the introduction of updates that better reflect real building functions (I04, I05, I06, BI03).
- d. *The introduction of benchmarks or reference guidance:* These would provide an indication of the predicted emissions that are to be expected from typical building types/heating and cooling systems configurations (I14).

#### **7.4.8.2-Software Tools**

- a. *Increasing the usability of tools:* The introduction of clearer and more user-friendly tool interfaces (I08). Specifically, it was recommended that either a user-friendly interface for SBEM be developed (BI07) or a simpler default tool be introduced.
- b. *The facilitation of more representative HVAC systems modelling:* To increase design flexibility and produce more realistic results (I06, I07). Although drop-down boxes provide an easy and fast input method, it is highly restrictive. It was suggested that the provision of clearer guidelines and the provision of training on the correct way to represent different types of systems (I05) should be included.
- c. *Introducing an integrated solar overheating check for all tools:* To enable integrated checking of the overheating requirement (BI05, I09, I15).
- d. *The revision of accreditation procedures:* To allow for the sufficient validation of calculation algorithms, the production of results and detection of errors (I01, I06, I10).
- e. *The synchronisation of the software development and regulatory revision cycle:* To enable software developers adequate time to develop and validate tools (BI06).



#### 7.4.8.3-Enforcement and Inspection Procedures

- a. *Better communication of legislative aims:* The improvement of the methods used to outline the requirements pertaining to energy efficiency in buildings in general and Part L and its implications on projects in particular. This would address the scepticism that has existed with regard to the environmental and policy drivers that underlie it (BI01, BI03) and better inform all parties of the exact requirements involved.
- b. *Improving enforcement capability:* Through updating training infrastructure and increasing the involvement of BCBs (I04). In addition, improving integration with planning requirements imposed by local councils to avoid confusion and to better organise compliance implementation (I14).
- c. *The introduction of a clear enforcement system:* To clarify responsibilities of building control (compliance enforcement) and planning (policy formulation) with regard to energy efficiency regulations. It was suggested the building control body should primarily oversee compliance enforcement, while planning should concentrate on policy matters (BI05).
- d. *Better integration of Part L 2006 and EPCs:* To organise and integrate the information required for each and standardise their use on projects (BI02). It was suggested that measures be adopted to introduce tax breaks for buildings that achieve a high EPC rating to encourage the uptake of energy efficient design (BI04).
- e. *Increasing the integration/transferability with the end-product:* Through the development of a project life-cycle compliance tracking system, increasing clients or other stakeholder understanding (I02) and the introduction of post occupancy evaluation studies to compare the outcome of 'design' compliance to 'built' compliance.
- f. *The implementation of mandatory inspections:* To eliminate the system of inconsistencies that was detrimental to the enforcement of Part L2A (BI01, BI03, BI04, BI05). Since there was no current requirement for mandatory inspections, some authorities had implemented a risk-management system on a trial basis (BI08), however it was widely viewed that statutory inspections should be introduced.

#### Chapter Summary:

- In the context of this study, interviews were carried out with the two groups of *Key Informants* involved in the decision-making process associated with the Part L2A compliance process.
- As part of a mixed-methods research methodology adopted in the study, the interviews were based on a standardised open-ended approach.

- A purposive sampling strategy for the recruitment of participants was employed.
- A set of selection criteria was developed to ensure that participants selected were representative of the overall target group and offered varied perspectives that enabled the transferability of findings.
- The process of data analysis was carried out using Computer Assisted Qualitative Data Analysis Software (CAQDAS) and adopted a cross-case approach.
- The main findings of the interviews include:
  - The importance of energy legislation had increased over the past few years and was in general expected to continue doing so.
  - There was a tendency for Part L to be viewed as a regulatory requirement rather than a sustainability issue,
  - The introduction of the Part L2A amendments had initiated organisational changes within industry.
  - The format, scope and function of roles in the direct implementation of Part L2A varied greatly.
  - Successful models of implementation that provide effective compliance process application included the use of a compliance pre-check 'indicative study'.
  - Early involvement during the C-D design stages is preferred.
- The main issues with the process that were highlighted include:
  - The increased complexity and specialisation affecting the implementation of the methodology.
  - The assessment of the process was significantly influenced by other factors such as the quality and capability of the available software.
  - A lack of clarity in the application and integration of the multiple energy efficiency targets.
  - More integration between Part L and other sustainability targets was required.
  - The need for more stringent enforcement measures was prioritised.
  - The confusion created by continual amendments was highlighted.

## Chapter 8: Comparative Analysis of Accredited Building Energy Performance Prediction Tools

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*To address the functional complexities and volumetric variability found in the UK non-domestic building stock (Pérez-Lombard et al. 2008; Bruhns 2008), the methodology for demonstrating compliance with energy performance criteria outlined in Approved Document Part L2A (ADL2A) allows the use of a variety of accredited BEPP tools. The issue of the occurrence of predictive variability widely acknowledged in previous work in this field was confirmed by the analysis of findings from industry surveys and interviews, which also outlined other major issues such as tool applicability limitations, predictive inconsistencies and consequent results variability. This chapter describes an inter-model comparative study that was undertaken in an aim to investigate these issues and outline the possible implications concerning the credibility of the overall approach.*

### 8.1-Comparative Analysis of Accredited Tools

The issue of predictive accuracy and results variability associated with energy performance prediction tools has been the subject of various studies, which were discussed in detail in Chapter 3 (3.5.2). In the case of compliance assessment and verification, it is a particularly important due to the associated regulatory implications and consequent impact on industry confidence in the applicability performance-based standards.

In the case of ADL2A compliance, while the testing procedures used in the tool accreditation process aim to diagnose and eliminate internal sources of error in calculation algorithms, findings from an early assessment of these tools (Carey 2006b) found that it did not necessarily ensure consistency in the results produced. Furthermore, results from the wide-scale UK industry survey show that this is a widespread concern (Raslan & Davies 2010; Raslan et al. 2007; Raslan & Davies 2006); with a significant proportion of participants reporting that in the majority of cases where a single user used multiple tools to model the same building, measurable differences and frequent inconsistencies in results occurred.

In an aim to investigate the potential occurrence of variability in the results of ADL2A accredited tools, a preliminary study (Raslan et al. 2009) was undertaken for a sample of accredited BEPP tools. This study analysed of two indicative output parameters: CO<sub>2</sub> emissions benchmarks and annual energy consumption. The results confirmed a lack of consistency between the generated benchmarks for both parameters for all the test models.

Consequently, to investigate the extent and possible causes of this variability and determine the possibility of further inconsistencies, a comprehensive study that analysed a wider variety of key parameters from the results generated by all accredited BEPP tools that were available at the time the exercises was implemented (April 2009). In an aim to expand on the largely limited previous assessments of accredited tools (Carey 2006; Raslan et al. 2009) and produce findings applicable to the overall UK non-domestic stock, the methodology adopted in this study was based on three main principles:

- The extension of the range of tested BEPP tools to include all updated and newly accredited versions available.
- The selection of test case studies that could be considered representative of the overall non-domestic building stock.
- The extension of key parameters used in the comparative analysis.

## 8.2-Study Methodology

Software testing can be conducted through a variety of approaches that differ according to the objectives and scope of the test (Witte et al. 2001). Table 8.1 lists the three main testing methods used in this field that were first outlined in the Energy Conservation in Buildings and Community Systems program (ECBCS) (CIBSE 2006; Judkoff et al. 1983).

Table 8.1: Software testing methods  
Source: Neymark & Judkoff 2002

Testing Approach	Scope	Advantages	Disadvantages	Examples	
				Envelope	Equipment
<b>Analytical</b>	<b>Test of solution process</b>	<ul style="list-style-type: none"> <li>• Inexpensive</li> <li>• No input uncertainty</li> <li>• Exact mathematical truth standard for the given model</li> <li>• Approximate truth standard within experimental accuracy</li> </ul>	<ul style="list-style-type: none"> <li>• No test of model validity</li> <li>• Limited to highly constrained cases for which analytical solutions can be derived</li> </ul>	<ul style="list-style-type: none"> <li>• Task 22 Working Document</li> </ul>	<ul style="list-style-type: none"> <li>• HVAC BESTEST</li> </ul>
<b>Comparative</b>	<b>Relative test of model &amp; solution process</b>	<ul style="list-style-type: none"> <li>• Inexpensive &amp; quick</li> <li>• No input uncertainty</li> <li>• Applicable at any level of complexity / facilitates diagnostic comparisons</li> </ul>	<ul style="list-style-type: none"> <li>• No truth standard</li> </ul>	<ul style="list-style-type: none"> <li>• IEA BESTEST</li> </ul>	<ul style="list-style-type: none"> <li>• HVAC BESTEST Vol.2</li> <li>• RADTEST</li> </ul>
<b>Empirical</b>	<b>Test of model &amp; solution process</b>	<ul style="list-style-type: none"> <li>• Approximate truth standard within experimental accuracy</li> <li>• Applicable at any level of complexity</li> </ul>	<ul style="list-style-type: none"> <li>• Experimental uncertainties</li> <li>• Entails expensive &amp; time consuming measurements</li> <li>• Only a limited number of test conditions are practical</li> </ul>	<ul style="list-style-type: none"> <li>• ETNA/GENEC</li> <li>• BRE/DMU</li> </ul>	<ul style="list-style-type: none"> <li>• Iowa ERS-VAV &amp; Daylighting -HVAC</li> </ul>

These testing procedures can be used for a number of purposes (Neymark & Judkoff 2002), examples of which include:

- The comparison of various tools to determine the degree of disagreement among them.
- The diagnosis of the algorithmic sources of prediction differences among various tools.
- The comparison of predictions from tools to benchmark analytical solutions and simulation results.
- The verification of the effect of any internal code modifications in new tool versions.
- The identification of algorithmic sensitivities.

For this study, a comparative testing approach in an inter-model format was selected (Figure 8.1). In general, the inter-model comparative format involves the use of a single test model and results generated by various tools are then compared. This approach has been widely used in investigating predictive variability, some examples of which include:

- A comparative study of five widely used tools in France to predict the energy performance of an experimental low-energy building was carried out (Brun et al. 2009). The study found that while a general degree of harmony existed between the results from a simplified base case, a significant variability in results (up to 60%) between tools was observed when specific input parameters were modified.
- In Neymark et al. (2002) the comparative testing of seven tools using a number of simplified test cases indicated that a 4–40% average disagreement between tools (versus the mean energy consumption results) existed. Further testing after the application of HVAC BESTEST diagnostics showed a marked improvement occurred in the final analytical solution results.

While this method provides a more flexible approach than either analytical or empirical testing (Hensen 2008), various practical limitations have been associated with it. This includes the difficulties that are associated with the standardisation of data inputs and outputs, which can lead to significant uncertainty in performing inter-model comparisons (Hensen 2008). Additionally, the methodology does not provide an absolute standard or measurement of program accuracy.

In this study, each of these issues was addressed by adopting measures to ensure the statistical validity of results (section 8.3) and increase the standardisation of inputs (section 8.4). Consequently, the findings of this study can be considered representative of the general case.

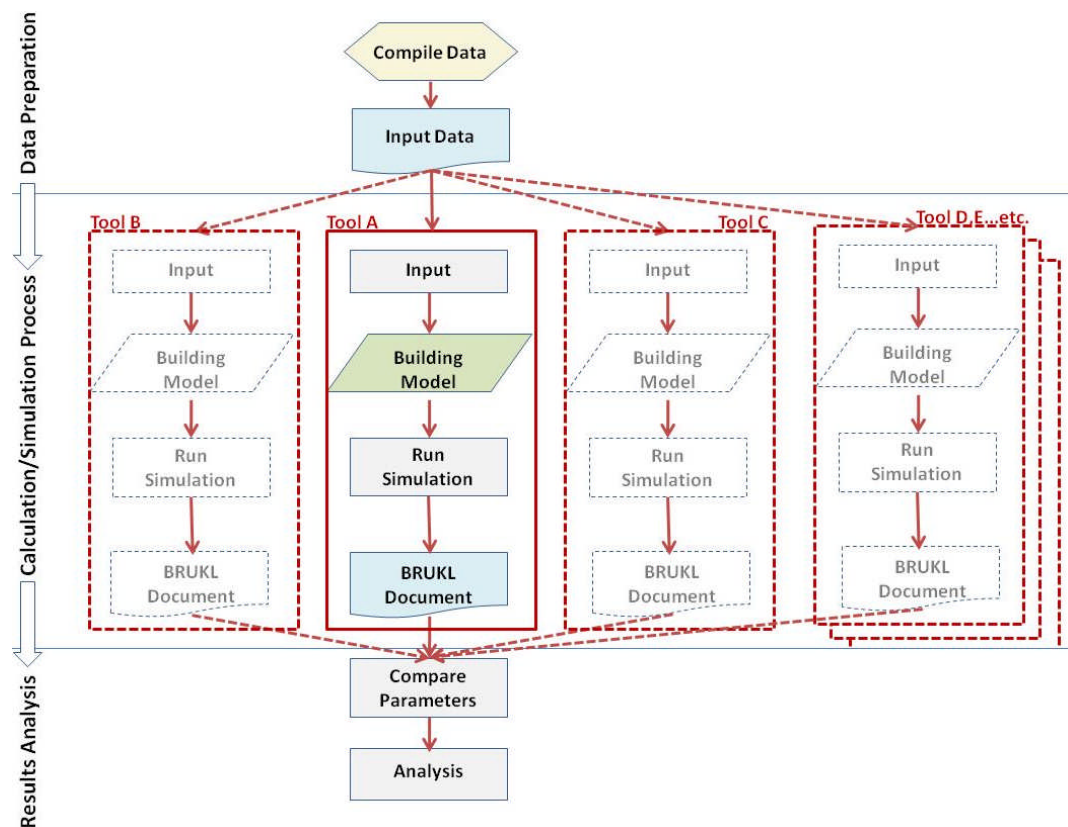


Figure 8.1: Inter-model comparative study methodology

### 8.3-Variant Models

Previous research suggests that in the case of a comparative study that involves a large number of potential variables, the use of a simple standard model is preferred. The Appendix A iSBEM tutorial model (DCLG 2007) was used by Carey (2006b) in the previous assessment. For both the preliminary and final phases of this study, the determination of more suitable test models was undertaken to ensure that the following two main criteria were fulfilled:

- The test model should be *representative*: i.e. it should adequately reflect the variety of uses and forms found in the non-domestic building sector.
- The test model should be *repeatable*: i.e. maintain a degree of simplicity to ensure repeatability with respect to the modelling task and the range of tools included.

Accordingly, the three simplified physical building variants outlined in the UKGBC report 'Report on Carbon Reductions in New Non-Domestic Buildings' (UKGBC 2007) for the analysis of zero carbon options were used (Figure 8.2). These single-zone models were based on work carried out for the Carbon Visions Building (CVB) program and the Non-Domestic Building Stock (NDBS) project and are considered to be representative of the main typologies that cover much of the UK non-domestic stock (H. Bruhns personal communication, April 2008).

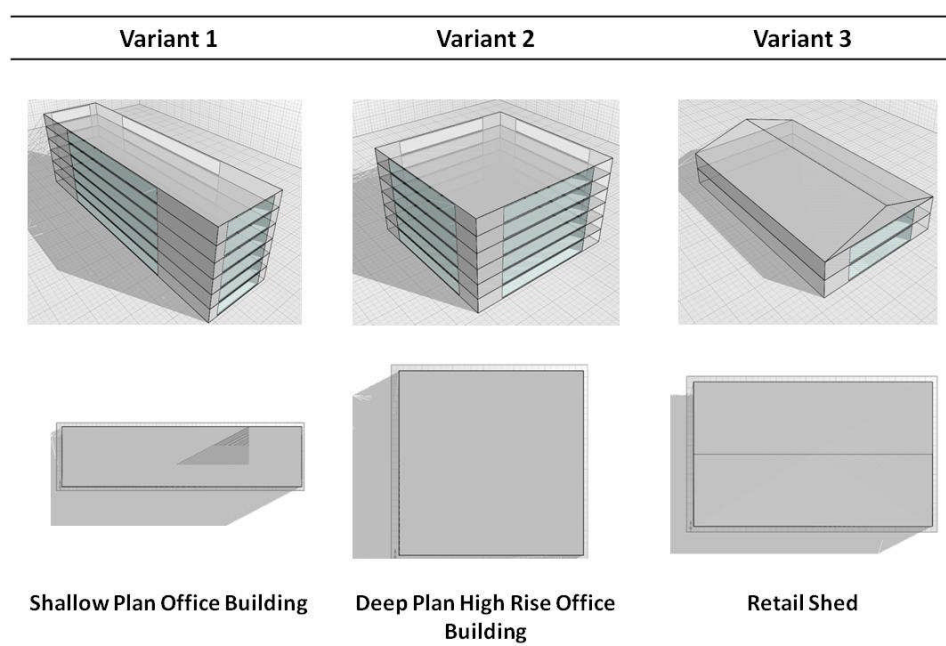


Figure 8.2: Study model variants and key modelling assumptions

## 8.4-Modelling Assumptions and Input Data

The full list of detailed data inputs used in the UKGBC report was obtained through personal communication with the report authors. Through the assessment of factors such as the technological capabilities of the range of accredited tools and the practicality of the overall task time, it was concluded that an approach of using a modified version of the technical specifications outlined would be more feasible than using the original UKGBC report input data. The modified inputs for each of the variant models are detailed in Appendix G. To ensure the consistency of specification and accuracy of this input data, the key thermal and physical properties were determined in accordance with the following factors:

- **Source modelling data:** Building geometry, zoning data, thermal characteristics of constructions and renewable energy strategies were selected to reflect the input data outlined in the UKGBC report. Alterations to inputs such as U-Values were made to realistically reflect those of (commercially) available building materials.
- **Software capability:** HVAC systems described in the UKGBC report were substituted with alternatives that reflected current technologies used in similar building types and could be modelled by all tools included in the study.
- **Regulatory compliance:** Modelling assumptions regarding HVAC and DHW systems were made in accordance with requirements outlined in the 'Non-Domestic Heating, Cooling and Ventilation Compliance Guide' (DCLG 2006a), which sets out minimum provisions for compliance with Part L2.

## 8.5-Modelling Methodology and Implementation of the Exercise

During the initial phase of the study, six out of a possible 12 accredited BEPP tools, representing all tool options were analysed. For the final stage, the scope of the study was expanded to include the latest available versions of all 12 accredited tools available at the time the study was undertaken. To minimise possible variations in results arising from external causes, the modelling exercises were implemented according to the following principles:

- *The use of a single modeller:* As discussed in Chapter 3, studies analysing the influence of user related factors on predictive variability (Guyon 1997) have shown differences of 40% in results from the same model can occur between different users. User related factors can influence aspects of the modelling process that include the derivation of building input files, model set up and abstraction, data interpretation, data input and results interpretation. To address this issue, all exercises were implemented by a single modeller with relevant engineering qualifications (BSc. /MSc.) and more than 3 years experience in the use of BEPP tools. The modeller was not yet registered under any of available schemes but had received formal training concerning the use of several accredited tools, including that undertaken by candidates for the BRE Competent Persons Scheme.
- *The minimisation of the use of external software:* The simplified variants and input variables were selected to suit the capabilities of all tools. However, in some cases it was necessary to use external software; this was limited to the following instances:
  - a. AutoCAD 2007: For the purposes of creating DXF floor plans of the variants for the building geometry creation for some tools such as Tas Building Designer modelling module, Design Database and ProCert.
  - b. PVSYST V4.33: For the purposes of defining PV system properties for the Tas PV Macro, which is a component of the Tas Building Designer Plant Sizing Macro, used for running Part L2 compliance calculations.

## 8.6-Results Analysis

For each of the tested tools, the modelling assumptions previously outlined were used to generate a building model. The calculation procedure was then implemented to produce the main 'as-designed' Part L2A compliance output- the Building Regulations UK Part L document (BRUKL)-in the standard format for each of the variants. To maintain anonymity in the detailed analysis of the results that is discussed in the following section, each tool is assigned a random designation (A to M) in which each of the calculation options available in IES VE (FI-SBEM /DSM) are identified separately.



### 8.6.1-Building Model Parameters

The building geometry and input data for each of the variants was entered according to the input methodology used for each tool. The following building model parameters were compared:

#### 8.6.1.1-Model Representation

Even though the input data was identical in all cases, Figure 8.3 illustrates the diverse methods of visualisation and varying degree of detail in model representation found in the range of accredited BEPP tools. The 13 models produced can be grouped into five main categories according to the complexity of the model as follows:

- The iSBEM interface provided the most basic type of representation, where the data associated with each of the building elements was displayed in an object tree format.
- FI-SBEMs produced either simplified 2D floor plans or abstract 3D models. In the case of the 2D plans, either a built-in or an external web-based viewer could be used to allow the 3D visualisation of each of the floors (e.g. the use of online VRML viewers in SpaceManager). While this provided a useful method for checking errors in building geometry, however the visualisation of the building in its entirety was not possible.
- DSMs generally provided more detailed models with additional features such as the display of annual shading patterns configured from shading calculations that were carried out by the tool. In the case of Tas, the calculation of the energy produced by rooftop PV panel installation required that they be geometrically modelled and assigned a material. The PVs were therefore geometrically represented in the building model.

#### 8.6.1.2-Building Geometry

The geometrical dimensions of the model derived from the 'Building Global Parameters' section of the generated BRUKL documents are summarised in Table 8.2. These show a general degree of consistency between the calculated total floor areas of the generated models and the dimensions outlined in the UKGBC report used in determining input data. However, in some of the generated models, a significant variation occurred in the calculation of floor area. For example, for Variant 2 this reached 83% and for Variant 3 a variation of 55% occurred.

In the case of the calculated external areas, the variation was far more considerable for all variants. Differences of up to 200% were frequently observed, which consequently impacted the assignment of external surfaces for the model. Since the model dimensions were in most cases identical, this would suggest the occurrence of errors in the assignment of surface adjacencies and calculation of external surface areas. The exact cause of these errors can be identified in some cases such as Variant 3, where some tools (mainly FI-SBEMs) did not recognise the pitched roof structure, and consequently did not include its dimensions in the calculation of the areas.


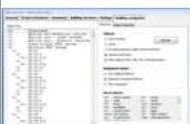

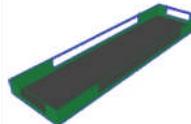
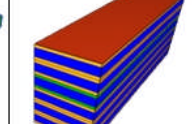
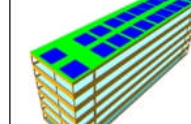


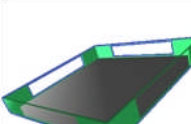
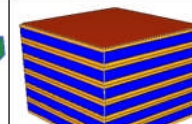
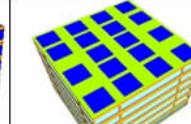


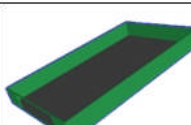
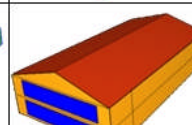
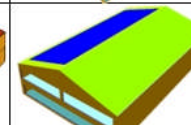
Degree of Detail				
				
Non-Graphical Model	Simplified 2D Floorplan	Simplified 2D Floorplan With 3D Zone Display	Abstract 3D Model	Detailed 3D Model
				
				
				
Non-graphical model where building data is represented in a format such as a structured object trees.	2D floor plans are used to create building layout and assign building elements.	2D floor plans are used to create building layout. Built-in or external viewer allows visualisation of selected zones.	Abstract 3D models with minimal detail. Rendering libraries may be used to display materials.	3D models with increased details such as shading patterns & PV panel distribution. Rendering libraries may be used to display materials.
ISBEM, QuickCert, SBEM Lifespan	GI-SBEM, Cymap, ProCert	Spacemanger, Design Database	CarbonChecker Designbuilder	Tas, IES(VE)

Figure 8.3: Examples of model variants representation

Table 8.2: Areas and external areas of generated models

Tool	Areas (m <sup>2</sup> )			External Areas (m <sup>2</sup> )		
	Variant 1	Variant 2	Variant 3	Variant 1	Variant 2	Variant 3
A	5400	5400	2000	6858	4464	3040
B	5400	5400	3000	5130	4464	4157
C	5315	5257	1970	4905	4381	2868
D	5139	5257	2292	3352	3067	4079
E	5400	5400	2000	10089	6684	3160
F	5400	5257	1947	5066	4405	3003
G	5400	900	2000	5095	1338	3040
H	5400	5400	2000	5130	4464	3040
I	5400	5400	2000	5130	4464	4338
J	5400	5400	3098	7388	13464	n/a
K	5400	5400	2000	5130	4464	3040
L	5400	5400	2000	5130	4464	3159
M	5310	5445	2897	5074	4487	3112
<b>Correct Values</b>	<b>5400</b>	<b>5400</b>	<b>2000</b>	<b>5130</b>	<b>4464</b>	<b>3166</b>
Min Value	5139	900	1947	3352	1338	2868
Max Value	5400	5445	3098	10089	13464	4338
Min Variation	5%	83%	3%	35%	70%	9%
Max Variation	0%	-1%	-55%	-97%	-202%	-37%

### 8.6.2-BRUKL Document Outputs

Table 8.3 presents a summary of the main observations concerning the expected and actual results of each of the output parameters and the relevant compliance criterion to which they apply. The analysis of each of these parameters is described in detail in the following sections.

Table 8.3: Expected and actual results of the study

Parameter	Compliance Requirement	Expected Results	Actual Results
<b>CO<sub>2</sub> Emissions</b>	-Criterion 1: Achieving an acceptable building CO <sub>2</sub> Emission rate (BER). -Criterion 4: Quality of construction & commissioning ( as built)	-Concurrence or close similarity between NOT, TER & BER predictions within the same class -Close similarity between results of SBEM & FI-SBEMs -Uniformity in Pass/Fail result for each variant	-Significant variations both between & within tool groups for all benchmark figures -Significantly lower predictions for DSMs -Inconsistency in Pass/Fail result for each variant
<b>U-Values</b>	-Criterion 2: Limits on design flexibility (design limits for envelope standards)	-Consistent calculated area weighted & individual U-Values for all tools	-Inconsistencies between calculated area weighted & individual U-Values for all tools
<b>Systems &amp; Infiltration Checks</b>	-Criterion 2: Limits on design flexibility (design limits for building services)	-Consistent systems efficiencies & air permeability values for all tools	-Consistent systems efficiencies & air permeability values for most tools. -Measurable variation in cooling efficiency values for one tool.
<b>HVAC Systems Performance</b>	Does not pertain to a particular compliance criterion, but may be used to provide further information for building control.	-Similarity between the generated results for annual energy demand & annual energy consumption for both the actual & notional building, especially within the same tool class	-A large degree of variability for both the actual & notional buildings

#### 8.6.2.1-Calculated CO<sub>2</sub> emissions

Table 8.4 summarises the results of predicted CO<sub>2</sub> emissions calculations (kgCO<sub>2</sub>/m<sup>2</sup>.annum) required for the demonstration of compliance with Criterion 1 of ADL2A for each variant. The main observations that can be made from the results are:

**a. A lack of consistency between tools in providing a pass/fail outcome for the same building:**

For two out of the three variants, there was a degree of inconsistency in the test variants achieving a pass/fail compliance outcome. In terms of the pass/fail ratio, this inconsistency varied between 12:1 for Variant 1 and 9:4 for Variant 3, which had a slightly more complicated building system, geometry and lighting zone distribution. It should be noted that for two of the 12 tools, the software only allowed the implementation and calculation of 'as-built' results rather than 'as-designed' results required in this study.

**b. A greater than expected degree of variability between the generated benchmarks for different tools**

Figures generally indicate that there were considerable variations between the predicted emissions benchmarks generated by all tools. In general, DSMs (Tools L-M) produced much lower predicted emissions rates for all benchmarks when compared to SBEM and FI-SBEMs (Tools A-K). For Variant 3 in particular, the difference between the maximum and minimum value of the  $C_{NOT}$  was approximately  $100 \text{ kgCO}_2/\text{m}^2.\text{annum}$ . Similarly, for the TER and BER, the approximate difference between the maximum and minimum predicted emissions reached  $70 \text{ kgCO}_2/\text{m}^2.\text{annum}$  and  $85 \text{ kgCO}_2/\text{m}^2.\text{annum}$  respectively.

Since the calculation engine SBEM was not intended for use as a design tool (BRE 2007a), these 'as-designed' results cannot be considered as absolute figures for actual building  $\text{CO}_2$  emissions and therefore cannot be directly compared. However, while it was not expected that these results be identical, the degree of variation between them raises the issue of if the extent of difference that exists between the various calculation methodologies is acceptable.

**c. A lack of clarity in the relationship between generated benchmarks**

The relationship between the BER, TER and  $C_{NOT}$  produced by each of the tools is illustrated in the table as the percentage improvement of the BER on each of these benchmarks, where:

- The percentage improvement of the BER on the  $C_{NOT}$  is indicative of the improvement in energy performance that can be expected with the introduction of an energy efficient approach to designing the building envelope and systems.
- The percentage improvement of the BER on the TER indicates the improvement on the legislative requirement.
- The relationship between the TER and  $C_{NOT}$  outlined in the compliance calculation equation (1) is defined by the improvement factor (IMP) and Low Zero Carbon (LZC) benchmark which are constant for each variant. This relationship can therefore be used to indicate the degree of consistency/inconsistency of generated results.

<p><i>When: <math>BER \leq TER \longrightarrow \text{Compliance}</math></i></p> <p><i>Where: <math>TER = C_{NOT} \times (1 - IMP) \times (1 - LZC) \dots \dots (1)</math></i></p>
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**Hence, the relationship between these benchmarks can be described as follows:**

- For a compliant building, the percentage improvement of the BER on the  $C_{NOT}$  should always be a positive value.
- For a compliant building, the percentage improvement of the BER on the TER should be either zero or a positive value.
- For all cases, the difference between the percentage improvement of the BER on the  $C_{NOT}$  and TER respectively should always be constant.

Even with the variation in predicted emissions for each tool, it was expected that the relationship between these benchmarks would be clearly discernible, where the percentage improvement of the BER on the C<sub>NOT</sub> or TER would either be constant or there would only be minimal differences between the percentages. However, the generated results did not reflect this and the variation in each of the cases followed a different pattern, which can be described as follows:

- **Variant 1**

The standard deviation<sup>15</sup> calculated for the generated benchmarks ranges between 11.4 and 17.4 which indicates a significant degree of variability. The BER improves on the C<sub>NOT</sub> by 28% and by only 1% from the TER in the Tool A calculation. This variation between the two benchmarks is more consistent (approximately 15-20%) for FI-SBEMs (Tools B-K) but the percentage improvement of the BER over both increases significantly in all cases. For DSMs (Tools L-M) the BER improvement on the C<sub>NOT</sub> is lower and the building fails in the Tool L calculation.

- **Variant 2**

Lighting is considered a major contributing factor in determining energy consumption for the office building typology used in this variant. Since a low energy LED lighting system was specified in this case, a large decrease between the TER and BER was expected. The standard deviation in this case ranged between 12.0 and 16.7 and results show a considerable variation between how tool classes factored in the lighting improvement. While a degree of conformity was found in the results of the DSMs (approximately 30% decrease between the BER and TER), in the case of SBEM and FI-SBEMs the results were disparate, ranging between 13% and 75%.

- **Variant 3**

Of all the test models, this case demonstrated the most significant inconsistency in the pass/fail outcome of the compliance check and the percentage of difference between TER and BER. The standard deviation here is considerably more than that calculated for Variants 1 and 2, ranging between 24.1 and 33.5.

However for this variant, a degree of consistency in the variation between the percentage improvement of the BER on the NOT and TER was observed within the DSM tool group.

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<sup>15</sup> Standard deviation denotes the spread of the data about the mean value and is a widely used measure of the variability or dispersion. The higher the standard deviation the more dispersed the distribution (Ayyub & McCuen 2003).

Table 8.4: Criterion 1-Predicted CO<sub>2</sub> emissions benchmarks

Variant 1 : Shallow Plan Office Building						
Tool	Emissions (kgCO <sub>2</sub> /m <sup>2</sup> .annum)			Pass/Fail	BER Improvement (%)	
	CNOT	TER	BER		CNOT	TER
A	75.3	54.2	53.9	Pass	28	1
B	72.9	52.5	28.6	Pass	61	46
C	69.9	50.4	37.2	Pass	47	26
D	89.3	64.3	50.0	Pass	44	22
E	108.6	78.2	60.4	Pass	44	23
F	88.8	63.9	53.2	Pass	40	17
G	88.8	63.9	54.4	Pass	39	15
H	88.9	64.0	54.2	Pass	39	15
I	73.4	52.8	47.7	Pass	35	10
J	89.4	64.4	61.1	Pass	32	5
K	89.5	64.5	34.4	Pass	62	47
L	43.6	31.4	32.6	Fail	25	-4
M	52.2	37.6	33.7	Pass	35	10
Summary Statistics						
Average	79.3	57.1	46.3			
Standard Deviation	17.4	12.5	11.4			
Variant 2 : Deep Plan Office Building						
Tool	Emissions (kgCO <sub>2</sub> /m <sup>2</sup> .annum)			Pass/Fail	BER Improvement (%)	
	CNOT	TER	BER		CNOT	TER
A	74.6	53.7	13.2	Pass	82	75
B	74.6	53.7	29.6	Pass	60	45
C	73.5	52.9	34.4	Pass	53	35
D	86.9	62.6	22.0	Pass	75	65
E	96.5	69.5	36.8	Pass	62	47
F	86.6	62.3	28.2	Pass	67	55
G	84.7	61.0	28.5	Pass	66	53
H	86.8	62.5	51.8	Pass	40	17
I	76.2	54.8	42.3	Pass	44	23
J	98.7	71.1	62.2	Pass	37	13
K	87.4	62.9	32.7	Pass	63	48
L	53.1	38.2	26.1	Pass	51	32
M	38.8	27.9	19.5	Pass	50	30
Summary Statistics						
Average	78.3	56.4	32.9			
Standard Deviation	16.7	12.0	13.2			
Variant 3 : Retail						
Tool	Emissions (kgCO <sub>2</sub> /m <sup>2</sup> .annum)			Pass/Fail	BER Improvement (%)	
	CNOT	TER	BER		CNOT	TER
A	170.5	122.7	111.7	Pass	34	9
B	108.1	77.9	80.0	Fail	26	-3
C	170.2	122.5	116.2	Pass	32	5
D	157.6	113.5	74.2	Pass	53	35
E	165.4	119.1	105.4	Pass	36	12
F	162.3	116.8	125.5	Fail	23	-7
G	162.0	116.6	123.7	Fail	24	-6
H	161.9	116.6	105.7	Pass	35	9
I	171.0	123.1	104.1	Pass	39	15
J	106.6	76.7	84.2	Fail	21	-10
K	150.5	108.4	58.9	Pass	61	46
L	93.3	67.2	52.8	Pass	43	21
M	77.2	55.7	39.4	Pass	49	29
Summary Statistics						
Average	142.8	102.8	90.9			
Standard Deviation	33.5	24.1	28.2			

### 8.6.2.2-Thermal Characteristics of Construction Elements

For the purposes of this exercise, the assigned U-Values for building constructions were determined in accordance with the methods and conventions as set out in BR 443: Conventions for U-Value calculations (DCLG 2006b), the properties of the construction elements for each of the variants was then input into each of the tools according to the input methodology used for each (e.g. drop-down menus, material and construction libraries...etc.). As part of the compliance process, the area-weighted average and individual element U-Values are calculated and compared with the defined 'limiting U-Values' in the BRUKL document to determine compliance with Criterion 2 of the ADL2A of the regulations (Limits on design flexibility - design limits for envelope standards).

Table 8.5 illustrates the range of U-Values calculated for each of the variants. Results show that there were several inconsistencies, most notably in the case of the two DSMs. Here, instead of the drop-down menus and boxes available for the input, elements not already available in the construction libraries had to be constructed using elements from the materials library available for each. Although care was taken to ensure that the 'constructed' U-Values and G-Values matched those defined for the input data, this may have contributed to the variation that was observed.

Table 8.5: Criterion 2-Calculated area weighted and individual U-Values of construction elements

Variant	Element	Modelling Assumption	Calculated Values Range			
		U-Value	Area Weighted U-Value Low	High	Individual U-Value Low	High
1	Walls	0.27	0.24	0.35	0.24	0.35
	Floors	0.22	0.11	0.25	0.15	0.35
	Roof	0.16	0.09	0.16	0.09	0.16
	Glazing	1.529	0.80	1.53	0.95	1.53
2	Walls	0.27	0.23	0.27	0.23	0.27
	Floors	0.22	0.11	0.25	0.15	0.25
	Roof	0.16	0.09	0.16	0.09	0.16
	Glazing	1.529	0.78	1.53	0.95	1.53
3	Walls	0.27	0.23	0.27	0.23	0.27
	Floors	0.22	0.11	0.25	0.14	0.25
	Roof	0.13	–	0.13	–	0.13
	Glazing	1.529	0.31	1.53	0.98	1.53

### 8.6.2.3-Systems & Infiltration Checks

Criterion 2 of ADL2A requirements state that HVAC system efficiencies for the cooling and heating, hot water source efficiency and specific fan power ratings should comply with design limits set out in the 'Non-Domestic Heating, Cooling and Ventilation Compliance Guide' (DCLG 2006a). Air permeability must also be tested and be less than a specified standard value applicable to most non-domestic buildings with an area above 500m<sup>2</sup> (10m<sup>3</sup>/hour/m<sup>2</sup> at 50 Pa).

Since key assumptions for all three variants were made to comply with requirements set out in the guide, all passed this requirement. In addition, given the similarity between the input procedures,

values relevant to systems and infiltration checks were largely uniform. However, for one particular tool (Tool H) the cooling efficiency was consistently 20-25% higher than in other tools.

### **8.6.3-HVAC Systems Performance**

For all model variants, the estimated energy demand and consumption from the BRUKL document were compared for both the notional (NOT) and actual (ACT) building (Figure 8.4 and Figure 8.5).

#### **8.6.3.1-Annual Energy Demand**

The estimated annual energy demand is an inherent characteristic of the building that relies on such factors as building fabric, geometry and activity and is measured in MJ/m<sup>2</sup>. Due to the consistency in the input data, a similarity between the generated results for both the actual and notional building was expected, especially within the same tool class.

However, results did not conform to the expected pattern and varied significantly between tools belonging to the same tool class. Nonetheless, a pattern was observed with DSMs producing lower energy demand results for both the actual and notional buildings than SBEM and FI-SBEMs. The calculated cooling demand far exceeded the calculated heat demand in most tools, which conforms to the expected pattern. An exception to this is the Tool M calculation for Variant 2, where the calculated cooling demand for the notional building was 0 MJ/m<sup>2</sup>.

#### **8.6.3.2-Annual Energy Consumption**

The annual energy consumption comprises the annual heating, cooling and auxiliary energy consumption, which are used to gauge HVAC systems performance and is measured in kWh/m<sup>2</sup>.

In addition to inherent building characteristics such as use, geometry and fabric, the calculation of annual consumption relies on factors such as HVAC system type and system efficiencies. Since each variant was assigned a single HVAC system in all tools, the results of the notional building were expected to be similar. A slight variation was expected in the results of the actual building due to such factors as differences in how system parameters are input (e.g. forms, macros, wizards), the increased degree of complexity and detail available for describing HVAC systems in DSMs and the different calculation methods employed in each tool class.

Results show a larger than expected degree of variability for both the actual and notional buildings for all the tools. For the notional building, the unexpected variation occurred between tool classes for all variants. For the actual building, where there was an even more significant difference, the variation occurred not only between different tools, but also within the same tool class. In general, DSMs (Tools L and M) seemed to produce lower energy consumption results for both the actual and notional buildings than other tools.





Figure 8.4: Calculated building energy demand

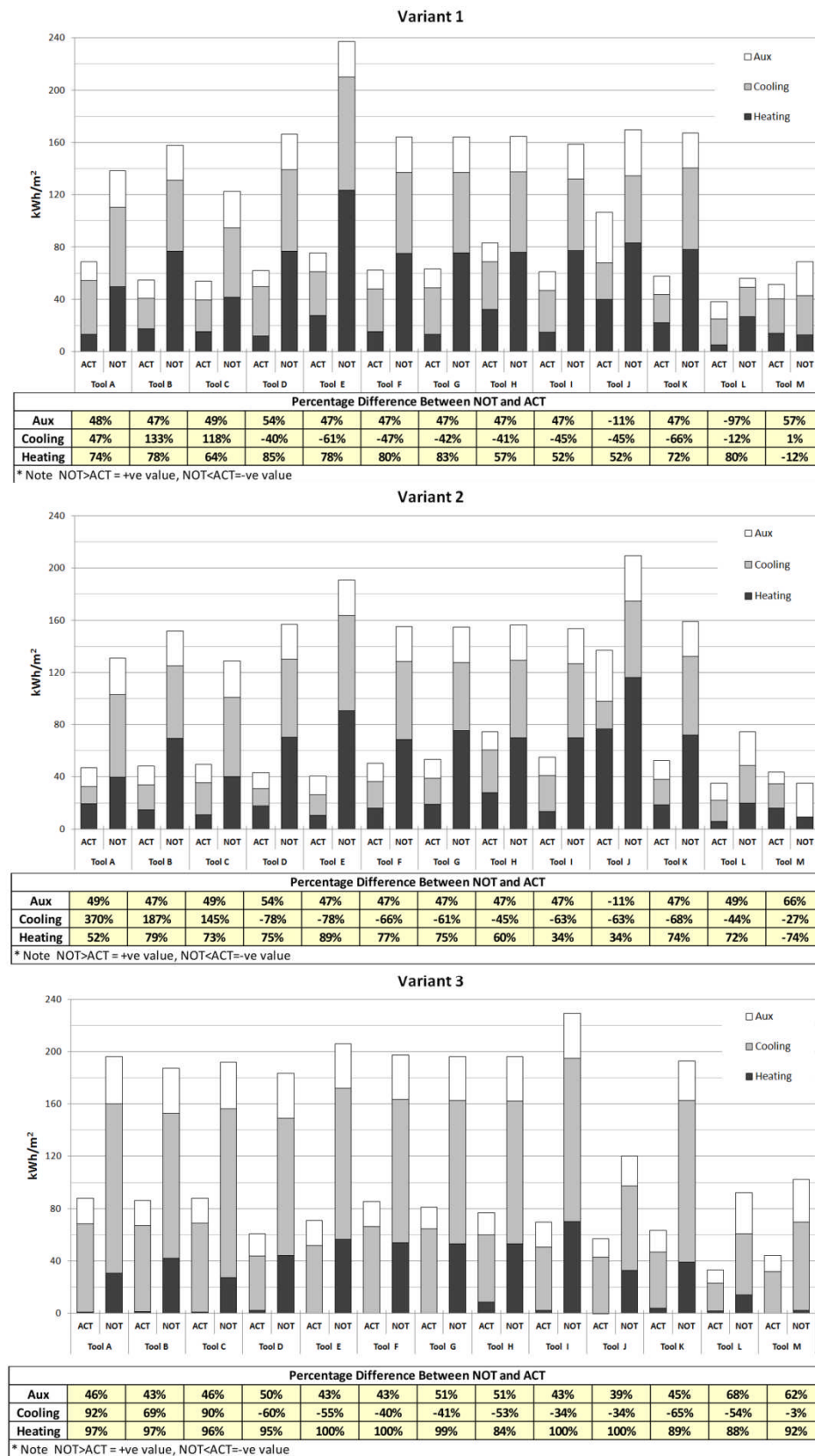


Figure 8.5: Calculated building energy consumption

## 8.7-Discussion of Results

The main findings of the study encompass issues experienced throughout the implementation of modelling exercises and from the analysis of the results. Since the study uses model variants that represent the main typologies found in the UK non-domestic sector and encompasses the range of accredited BEPP tools, it can be assumed that findings of this study hold a degree of statistical representation and can therefore be considered applicable to a large portion of cases covered by Part L2A compliance process. The main conclusions drawn from this study highlight several important issues, which include:

- *Limitations in the scope of applicability of accredited tools*

To allow for the realistic representation of a building and the accurate prediction its energy performance, BEPP tools should ideally model all aspects of a building that influence energy use and occupant comfort (Judkoff & Neymark 2006). Since the modelling of energy efficient strategies in particular is challenging, work undertaken in recent years has aimed to enhance the ability of BEPP tools to recognise the cooling benefits of strategies such as natural ventilation and Tri-Generation (Tarrant 2006). However, it has been previously established that the calculation capabilities of many tools, especially those employing traditional steady-state calculations (Bartholomew et al. 1997), cannot adequately represent innovative designs that incorporate natural or mixed-mode ventilation or other passive features.

In this particular study, only the two DSMs out of an overall 12 accredited tools were able to model the relatively complex HVAC systems and Tri-Generation CHP applications described in the original UKGBC report. Consequently, these were altered to suit the technological capabilities of all tools. Similar limitations were also experienced with modelling the lighting and DHW systems. Further limitations experienced with models not examined in this study but outlined in the NCM modelling guide (DCLG 2008c) include:

- Night ventilation strategies and ventilation with enhanced thermal coupling to structure
- Demand-controlled ventilation
- Automatic blind control
- Variable speed pumping
- Light transfer between highly glazed internal spaces such as atria or light wells

While the DCLG guidance (DCLG 2008, p.6.) describes the work required to address these limitations as being “not insurmountable”, in practice unless iSBEM and FI-SBEMs substitute the current SBEM calculation methodology with one that employs a dynamic modelling approach, the associated increase in the time and effort required in attempting to represent the effect of these systems, may discourage modellers from doing so in favour of more easily simulated fabric

improvements or renewable strategies. Moreover, it can be argued that the approach to representing such features relies heavily on approximation and is therefore both more prone to the associated user errors discussed in section 3.5.2 and cannot adequately reflect their actual effect.

Additionally, while DSMs are capable of modelling these systems, their use is also limited by factors such as relatively high software costs (e.g. a single annual user license is in excess of £1000) and the extensive training required to acquire the degree of proficiency for their use.

- *A lack of input data standardisation*

In order to provide consistency of application, standard measurement conventions must be used for all accredited BEPP tools. However, in many cases, this standardisation does not seem to apply to measurement units. Examples of where differences in units required conversion or calculation that occurred in this exercise include:

- Thermal properties of constructions: The use of the internal heat capacity ( $\kappa_m$  value- $\text{kJ}/\text{m}^2\text{K}$ ) in SBEM and FI-SBEMs provides a simplified means for the SBEM calculation engine to approximate thermal mass; however, DSMs do not use this method and employ a more accurate numerical solution to account for it. The use of the  $\kappa_m$  value as a technical specification of relevant building constructions is not an industry standard and is therefore not readily available. Since this value must therefore be calculated when required by each individual modeller using external (reference) guidance, it is also prone to user error (DCLG 2008).
- Infiltration rate: There was no standardisation in the units used for air infiltration. Both the air changes per hour (ach) and  $\text{m}^3/\text{m}^2/\text{hr}@50\text{pa}$  conventions were used by different tools.

In both these instances, due to the use of referenced calculation and conversion procedures the validity of resulting input data could therefore not be confirmed due to possible errors and inconsistencies.

- *Variability of between tool results and industry confidence in building energy simulation*

The results of this study highlight two important issues; a large degree of variability between the BER and TER produced by each of the tools and the lack of consistency in granting approval (a pass/fail result) for the same building.

Various studies analysing the outputs generated by performance prediction tools discussed in section 3.5.2 have shown that several factors may influence the predictive variability (e.g. Guyon 1997; Kalema et al. 2008; Judkoff 2008; Karlsson et al. 2007). In the context of this study, the first three of these factors can initially be eliminated due to the methodology utilised in the implementation of the exercises. Accordingly, the variations that exist between different tool

groups can therefore be assumed to be a product of factors attributable to the tools themselves, such as:

- Calculation methodology (quasi steady-state monthly average vs. hourly detailed dynamic simulation).
- Thermal modelling algorithms (SBEM algorithms vs. Tas/IES Apache algorithms).
- Additional capabilities of DSMs that allow the integration of solar shading and CFD calculation inputs.

In some cases, particular programming errors (as with the issue in assigning adjacencies described in 8.6.1.2) that may have contributed to these variations were identified and communicated with software developers. However, in most cases the causes of the variations within tool groups were less obvious. It can be therefore only be assumed that these are also a product of either tool error or possible user error in data input. Although similarity or consistency between results does not necessarily guarantee the accuracy of predictions (Hensen 2008), in either case, these variations raise the issue of the credibility of this methodology as a method of demonstrating compliance.

#### **Chapter Summary:**

- Various studies in the field have highlighted the issue of predictive variability in tools. This issue was also reported in the feedback from the industry study.
- A comparative testing approach in an inter-model format was selected to analyse the existence and extent of predictive variability in the range of BEPP tools accredited for Part L2A compliance demonstration.
- Three single-zone models, considered to be representative of the main typologies that cover much of the UK non-domestic stock were selected for the analysis.
- To optimise test conditions, measures were taken to ensure the consistency of specification and accuracy of the model input data. All exercises were implemented by a single modeller to minimise user-influenced variability.
- The main findings of the study encompass issues experienced throughout the implementation of modelling exercises and from the analysis of the results.
- The results of this study highlight two important issues; a large degree of variability between the BER and TER produced by each of the tools and the lack of consistency in granting approval (a pass/fail result) for the same building.
- Other issues include limitations in the scope of applicability of accredited tools and the lack of input data standardisation

## Chapter 9: Analysis of Data and Discussion

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*This chapter presents the analysis of the findings of the industry analysis and tool study reported in Chapters 6, 7 and 8, applied through the implementation of a data analysis triangulation methodology. The findings are related back to the literature discussed in the relevant sections of the research as well as the contextual issues specific to the implementation of the NCM outlined in section 4.5. The discussion is structured with reference to the main research objectives and the defined areas of interrogation: the adaptive capability of the UK construction industry; issues relating to implementation and enforcement of the methodology and, finally, the suitability of the tools provided. The implication of the changes in the upcoming revisions is also related to the findings. Finally, recommendations that address major issues are presented.*

### 9.1-Application of Data Analysis Strategies

The analysis of data was undertaken through the strategy outlined in section (5.3.2) where findings from each phase of the study - discussed in each of the relevant chapters - were integrated through the application of triangulation techniques. This allowed the inference of the overall findings of this research with respect to the outlined objectives.

Although the qualitative data (perceptions and observations) from the interview portion of the industry study did not aim at quantification (Kvale 2007), it was used to further clarify and supplement findings of the quantitative portions of the survey portion of the study through the addition of explanations and perspectives. This triangulation of distinct methods provides greater opportunities for causal inference (Brewer & Hunter 1989).

For most cases, as shown in Figure 9.1, the relationship between the data derived from the industry survey and interviews was for most part either *confirmatory* or *complimentary*, and therefore could be either used for corroboration or combined together to generate insights. Data from the tool analysis (when applicable) was generally *elaborative*, clarifying industry findings and exemplifying how they applied in practice. In the few cases where data was *contradictory* further analysis was carried out to determine the cause.

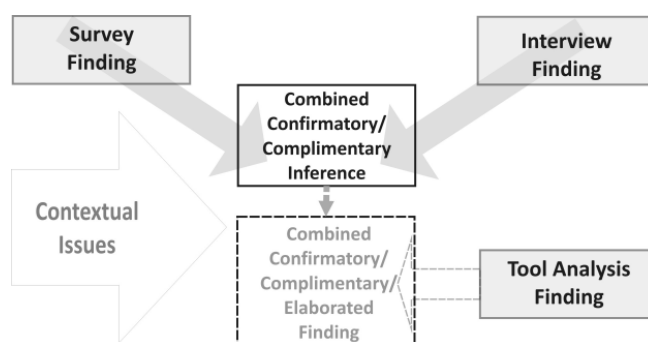


Figure 9.1: Data analysis model

## 9.2-Findings of Data Analysis

The discussion of the findings is structured with reference to the 'parameter of success' defined for each of the research objectives outlined in section 1.2. These are assessed according to the evaluation criteria defined for each. The main findings are summarised in Table 9.1 and discussed in detail in the following sections.

Table 9.1: Summary of research objectives, criteria of evaluation and findings

Research Objective 1: Assessment of the impact of the introduction of the NCM		
<b>Parameter: The adaptive capability of the UK industry</b>		
Criteria	Organisational Adaptability	Some changes occurred on the organisational scale. However rather than being pervasive, adaptability measures were undertaken within a framework of increased specialisation.
	Skills adaptability	Occupational specialisation occurred, but there was little increase in the uptake of formal training and certification to meet skills demand and maintain quality.
	Tool adaptability	An increased number of tools were developed but this did not translate into major improvements in terms of their technical capability.
Research Objective 2: Evaluation of the effectiveness of the methodology		
<b>Parameter: Application and enforcement</b>		
Criteria	Applicability of the methodology	Various complexities in understanding the dynamics of its implementation have affected its overall applicability.
	Integration of Part L2A/NCM	Part L was still considered a legislative requirement rather than a sustainability target or part of an integrated design process (a specialist function).
	Dynamics of application/enforcement	In the absence of sufficient procedural guidance, the dynamics of implementation and enforcement varied greatly.
	Issues & Priority Areas	The complexity and various technical limitations associated with compliance tools were highlighted as the main concerns.
Research Objective 3: The determination of the suitability of tools		
<b>Parameter: The technical capability of tools and viability of results</b>		
Criteria	Tool Usability	The quality of user interfaces for many of the accredited tools, especially the default tool, was considered to be poor.
	Tool Capability	Limitations in the calculation capabilities of many tools, especially those employing traditional steady-state calculations deemed them inadequate for modelling innovative /energy efficient designs features.
	Tool Reliability	The variability found between compliance results was far more extensive than desirable and resulted in a lack of consistency in granting approval (a pass/fail result) for the same building.

### **9.2.1-The Adaptive Capability of the UK Construction Industry**

This study sought to assess the impact of the introduction of a modelling-based approach to energy performance compliance verification on the UK construction industry. This was undertaken through the provision of an evaluation of the status of the initial industry capabilities and the subsequent changes as a measure of the adaptability to support the NCM. The findings in this section were mostly derived from the industry survey, corroborated by interview findings and elaborated on where appropriate by the integration of the tool study findings. This section discusses the findings relating to adaptability in three main areas; organisational adaptability, skills adaptability and tool adaptability.

#### **9.2.1.1-Organisational Adaptability**

The introduction of the NCM as an approach to Part L2A compliance initiated some changes on the organisational scale. However, rather than being pervasive and evoking development in the working practices of the organisation as a whole, adaptability measures were undertaken within a framework of increased specialisation. Survey results indicated that the primary activity of organisations undertaking the implementation of compliance tasks shifted from architectural design firms to multidisciplinary organisations within which specialised groups with expertise in areas relating to building services engineering and environmental design consultancy existed. These had the organisational structure and the resources required to support what had come to be primarily considered as a specialist function.

Consequently, this resulted in the Part L2A process being dealt with as a largely isolated task that related to building regulations compliance rather than achieving the underlying objective of being a fundamental stage in an integrated process of energy efficient building design. On the organisational scale, even though the use of other software types was widespread, the proliferation of energy modelling beyond the specialist function groups remained limited. As a result, energy analysis tasks were in most cases not undertaken during earlier design stages (e.g. schematic design), where performance prediction is widely considered to be most effective in informing design decisions (e.g. Bradley 2009; Cutler et al. 2008; RIBA 2007).

Interview findings largely confirmed this trend and further highlighted the gap that existed in the uptake of adaptability measures between organisations concerned with the implementation (Industry) and enforcement (Building Control Bodies).

#### **9.2.1.2-Skills Adaptability**

Trends regarding user skills closely followed those found on the organisational scale, with an increase in specialisation towards more technical professions. Survey results illustrate an increased specialisation in the occupation of those who undertook Part L2A compliance



calculations from architectural/design-based functions to more technical based professions such as building services engineering and environmental consultants.

During the initial implementation stage of the NCM, survey results regarding respondent experience suggested that the field of energy performance attracted relatively (less experienced) newer graduates with specialised degrees in the field. This was confirmed by the industry interview participant data where 10 out of 15 of those interviewed had less than 6 years experience, which suggests that they were specifically recruited for this purpose. In following the general trend in industry, more experienced participants usually assumed supervisory roles rather than undertake the calculation exercise themselves.

There was little increase in the uptake of formal training and a general growth in the reliance on self-instruction was observed with survey respondents. Similarly, interview participants attributed the attainment of the knowledge and basic skills required to a specialised degree in the field where they might also have been trained to use a particular software tool, this was referred to as a 'pre-trained user base'. A targeted training approach was often adopted within organisations, where most training activities were undertaken in the context of the workplace. The uptake of formal certification was also low, where over half of all survey respondents and over a third of interview participants had not participated in any of the available certification programs. There was also a large degree of confusion with regard to these certification programs being mandatory or non-mandatory.

#### **9.2.1.3-Tool Adaptability**

In relation to the previous two areas, adaptability with regard to tool development as shown in the expansion in the range of accredited BEPP tools between the phases of the survey study was relatively higher. The increased number of accredited tools which became available during the second survey, suggests a degree of progress in the software development cycle.

During the initial implementation stages of the NCM, in addition to the three accredited tools, a large percentage of respondents reported that they also used or intended to use other in-house or non-accredited tools. The increased scope of tools resulted in respondents exploring the use of multiple tools, but the uptake of new tools (most of which were FI-SBEM class) remained relatively low compared to the more established ones. Interview participants also confirmed this finding, relying on DSM tools to both undertake the Part L2A calculation and associated analysis such as modelling the effect of introducing renewable technologies, which they felt were beyond the technical scope of SBEM or FI-SBEMs.

The development of new tools (or new tool versions) did not necessarily translate into major improvements in terms of technical capability (especially SBEM). Furthermore, the number of

major issues that emerged when these tools were used in practice (such as modelling errors and inconsistencies, data entry procedures and compatibility issues) remained largely unresolved. This is important since a strong relationship between user rating of the efficiency of the methodology and the tool used was established.

### **9.2.2-The Effectiveness of the Methodology: Application and Enforcement**

This section discusses the findings relating to the effectiveness of the methodology with regard to both its application and enforcement in the following four main areas; the applicability of the methodology, the integration of the methodology, the dynamics of application and enforcement and issues and areas of priority. The inferences in this section are mainly based on interview feedback corroborated by the trends outlined in the survey findings.

#### **9.2.2.1-Applicability of the Methodology**

The majority of industry participants interviewed stated that the fundamental idea underlying the NCM was in principle useful and had in some ways contributed positively to the overall energy efficiency agenda. Despite these advantages, various complexities in understanding the dynamics of its implementation were singled out by interview participants as the main issue affecting its overall applicability. Given the magnitude of change that was required by industry to accommodate the new methodology, it is understandable that this was the case.

The unpopularity of the previously used Carbon Emissions Method, on which the approach of the NCM was based, indicates that there was an issue with the industry's initial apprehension in utilising a holistic approach to energy performance compliance, preferring the more prescriptive (and relatively more straightforward) Elemental Method. Industry assessment of the NCM in its initial stage of implementation rated it as 'unsatisfactory', where the issues of its efficiency and usability were highlighted. Over a year after its introduction, while familiarisation with the approach led to a slight overall improvement in its assessment to 'satisfactory', issues pertaining to its validity became a concern, where the perceived efficiency of the methodology in particular was impacted by tool choice.

The introduction of the NCM methodology involved an increase in workload for design teams where more work and various tasks were required to demonstrate compliance. For BCBs the applicability of the methodology was even more problematic, due to the fact that their expertise mainly lay in the domestic sector. Consequently, in addition to the increased workload, the enforcement of the methodology also required the assistance of specialist support to aid in the understanding of procedures.

### **9.2.2.2-Integration of Part L2A/NCM**

The importance of energy legislation had increased over the past few years and was expected to continue doing so. The legislative integration of energy performance prediction was viewed to have in some ways aided the move of energy efficiency from best practice to a legal requirement. However, even though Part L was considered a key aspect of any building project, its potential to contribute to the energy efficiency agenda was limited by two factors:

- Due to the dynamics of its application, it was viewed as a legislative requirement rather than a component of an integrated approach to energy efficient design.
- There was a lack of integration between Part L and other sustainability targets.

Survey findings concerning accredited BEPP tool use further highlight this issue. A considerable percentage of respondents used energy performance prediction tools for general energy performance improvement applications, which suggests an increased awareness and demand for improving the energy efficiency of buildings for purposes beyond legislative compliance. However, the use of accredited BEPP tools was increasingly confined to the sole purpose of Part L2A compliance calculation, even if the tool had more sophisticated analysis capabilities (e.g. IES and Tas).

### **9.2.2.3-The Dynamics of Application and Enforcement**

The dynamics of application varied greatly between the implementation of the methodology and the enforcement of its requirements. In the absence of procedural guidelines, industry professionals had developed their own approaches to ensure effective implementation. However, the enforcement procedure (particularly where LABCs were involved) had not adapted in the same manner.

In implementation, the effectiveness of procedural models developed as a result of individual efforts was recognised. An example of this was the 'indicative study' approach, where the compliance tools are used to assess the feasibility of options as detailed in section 7.4.3.2. Since this approach relied on early involvement and continuous feedback between various stakeholders throughout the design process, compliance checking contributed to informing the decision-making process and compliance tools were used in a design capacity.

The use of such models is not yet universal, but the initiative taken in adopting the approach indicates the potential and propensity for moving towards a more integrated design process. Here, guidelines already put in place to outline the submission process could be extended to provide advice on effective implementation procedures, relating them to project scale, definitiveness of the design and planning requirements.

The enforcement process had the potential to greatly affect the effectiveness of methodology. In addition to ensuring compliance, BCBs also had the ability to inform the design process and provide compliance option advice. However, the applicability and validity of this advice is limited by factors such as their general unfamiliarity with regard to the compliance tools and the degree of inconsistency relating to the understanding of the methodology that was observed in the general confusion regarding the accreditation requirements of methods, tools and individuals.

#### **9.2.2.4-Issues and Areas of Priority**

The analysis of interview responses outlined several areas of concern, which both groups felt should be prioritised in upcoming revisions. These included the complexity of the methodology and various technical limitations associated with accredited BEPP tools (especially the default SBEM tool). Suggestions included the integration of a solar overheating criteria check facility within all accredited tools, the provision of sufficient procedural guidance/training to address the complexity of the methodology and the introduction of measures to eliminate the lack of consistency in enforcement and the lack of clarity in application.

With regard to legislative revision procedures, when the current amendments were introduced the use of transitional provisions was reported to have caused significant confusion. This was compounded by an insufficient lead-in period and inadequate provision of procedural information outlining the changes. A period of 4 years for the 2006-2010 review was considered sufficient to maintain achievable progress and it was recommended that the standstill period be extended beyond the current 6 months in proportion with the type and extent of the changes introduced with each legislation revision.

#### **9.2.3-Suitability of the Tools**

Feedback from both the industry survey and interviews outlined several issues regarding the suitability of the available accredited tools. These findings were further investigated through the implementation of the tool study, which highlighted concerns in three main areas; tool usability, tool capability and tool reliability. In considering these findings and further limitations outlined in the NCM modelling guide (DCLG 2008c), it can be assumed that due to the technological limitations in the scope of applicability of most accredited tools, the tool capability factor has yet to be fulfilled.

##### **9.2.3.1-Tool Usability**

An underlying belief that BEPP tools were more difficult to use than other traditional energy performance calculation methods limited the frequency of their use despite there being a general consensus that they did in fact provide more reliable results. Tool usability was widely considered to be a major factor in influencing tools selection decision, partially due to the fact that

the quality of user interfaces for many of the accredited tools was considered to be poor. Interview participants prioritised SBEM for the development of a more user-friendly interface or suggested that a simpler default tool be developed. During the implementation of the tool study, the limitations of the SBEM tool became evident, where the process required for the input of building geometry was the most time-consuming and labour intensive.

### **9.2.3.2-Tool Capability**

The tool study confirmed the issue of tool capability limitations reported in both the interviews and surveys. Only the two DSMs out of an overall 12 accredited tools were able to model the original input data first considered for the study. This included somewhat complex (but fairly typical) HVAC systems configurations and Tri-Generation CHP applications, with similar limitations experienced with modelling the lighting and DHW systems.

Further limitations not investigated in the physical models included in the exercises - but reviewed in relevant literature - have also established the shortcomings in the calculation capabilities of many tools, especially those employing traditional steady-state calculations (Bartholomew et al. 1997) and consider them to be inadequate for modelling innovative designs incorporating natural or mixed mode ventilation or other passive features.

While DSMs are capable of modelling these systems (and were therefore the tool of choice for industry interview participants) on a wider scale their use is also limited by factors such as relatively high software costs (e.g. a single annual user license is in excess of £1000) and the extensive training to acquire the degree of proficiency required for their use.

### **9.2.3.3-Tool Reliability and Results Variability**

The plausibility of results and reliability of tools were outlined as the most important factors with regard to the selection of general energy performance tools and more specifically, tools accredited for Part L2A compliance. However, results variability was reported by users of multiple tools, many of whom did not apply any quality assurance methods to assess their validity. Various parameters were identified as having a significant effect on the compliance outcome, causing variations of anywhere between 5-50% in the calculated CO<sub>2</sub> emissions.

Due to the various calculation approaches and underlying assumptions associated with the different tool classes, some difference was expected. However, the results of the tool study found that this variability was very significant in terms of its effect on the building achieving compliance. This both affected the calculation outcomes of the compliance benchmarks (BER and TER) produced by each of the tools and resulted in the lack of consistency in granting approval (a pass/fail result) for the same building. Some of the underlying factors that were identified as potential sources of this variation included the lack of input data standardisation and insufficient

accreditation procedures. For some accredited tools, the tool study uncovered some programming issues that were communicated with the developers.

### 9.3-Implications of Findings

The findings of this research imply certain general shortcomings in each of the three parameters defined to assess the experience of applying the methodology. The following section describes the impact of these findings on the wider scope of the general context of energy performance in buildings. In addition, since the building energy performance compliance is subject to a cyclic review process, the findings of the current amendments are related to the latest 2010 revisions and can be extended to informing future revisions planned for 2013 and 2016.

#### 9.3.1-Contextual Issues

In relating the findings of the research to the wider context, it is reasonable to assume that impact of the shortcomings that have been highlighted will extend to such areas as achieving the sectoral carbon targets, the realisation of the objectives of the EPBD and the effect on the actual energy performance of buildings that have gone through the compliance process. Each of these areas is discussed below.

##### 9.3.1.1- Achieving Sectoral Carbon Targets

An assessment of the cumulative impact of previous Part L amendments (1982, 1990 and 1995) found that the net effect of their implementation may have only achieved a third of the associated energy performance targets (Olivier 2001). Given the shortcomings that have been reported in this study it is envisioned that this will affect the realisation of associated sectoral targets. Figure 9.2 provides a simplified representation of the comparison of building sector emissions reductions expected from the EPBD and the 2006 amendments and what is actually achievable if the previous effect described by Olivier is applied. The significant difference indicates the importance of correct implementation in ensuring that associated targets are reached.

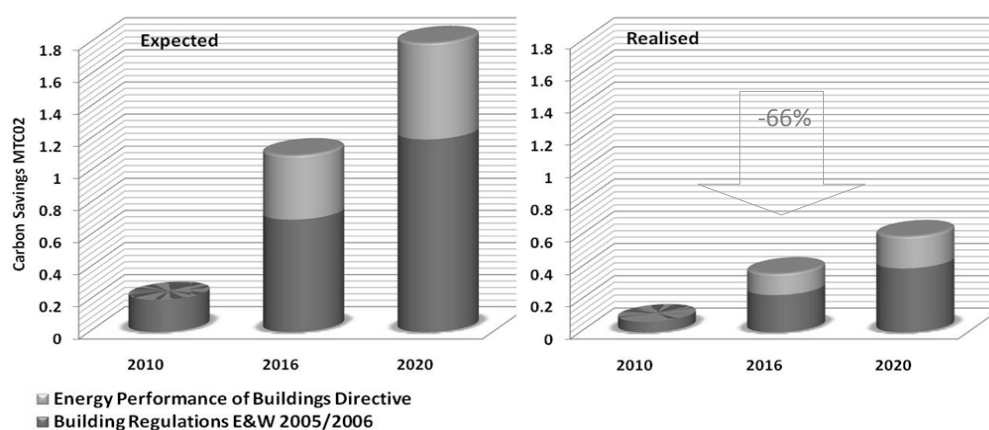


Figure 9.2: Expected and realised sectoral carbon targets  
Source: DEFRA 2007

### **9.3.1.2-Tool Capability and the Objectives of the EPBD**

The considerable limitations in the technological capability of the majority of accredited BEPP tools might not only impact the usability of the methodology, but may also in effect discourage or limit the use of more complex energy efficient technologies or design features, due to the presumption that their effect will not be adequately represented in the compliance document. It can therefore be concluded that the resultant effect of the current approach of demonstrating regulatory compliance has in some ways opposed, or hindered one of the main objectives of the EPBD: to consider the optimum use of factors relevant to enhancing energy performance and encourage the consideration of the positive influence of renewable technologies (Kokogiannakis 2008).

### **9.3.1.3-Measured Performance in Relation to Energy Performance Prediction**

In the context of building energy performance regulation, in addition to the 'as-designed' compliance calculations, accredited tools are also used for the following functions:

- The demonstration of compliance with Criterion 4 of ADL2A (quality of construction and commissioning), through the production of the 'as-built' results ('as-built' BER  $\leq$  'as-designed' BER).
- The production of non-domestic EPCs (energy performance certificates).

A degree of variation between the results of the 'as-designed' calculations and in the results of either of these applications should always be expected. This is due to factors such as design alterations, differences in operational practices, schedules, equipment and construction not anticipated in the energy modelling process. However, the results of this study suggest that a similar predictive variability between the tools when used for these applications will be highly likely. The implications of variation in either case are potentially very significant since they impact the certification, procurement, construction (Hamza & Greenwood 2009) and operation of the building.

This issue was recognised by DCLG, who in March 2010 introduced a requirement for all accredited tools to use the same version of SBEM (V3.5.a) to produce EPCs (AECOM/DCLG 2010). This offered a short-term solution, however it is reasonable to suggest that adopting more long-term measures that aim to narrow this range of variability will provide a statistically credible and more precise quantification of predicted energy performance improvements (Turner & Frankel 2008).

### **9.3.2-Future Regulatory Revisions**

Since the mid 1980s, the building regulations in the UK have undergone five major changes in an aim to improve public welfare and safety and-more recently-address the global call to improve

the energy performance of buildings. In an aim to extend the current regulations, DCLG defined various goals that future revisions should aim to achieve (DCLG 2008a). These are:

- Achieving a higher quality of construction through the development of robust standard details.
- Improving skills in the construction workforce.
- Facilitating innovation in construction materials, components and building design.
- Promoting a culture of continual improvement.

As part of the proposed changes outlined in the consultation document for the 2010 revisions, two options for achieving the government's objective of a further 25% reduction in emissions for the domestic and non-domestic buildings were set out. For the non-domestic sector, the following options for implementing the calculation to demonstrate compliance with Criterion 1 of the regulations were presented (DCLG 2009b):

- The Flat Approach: In this option, the 2002 notional building would continue to be used as the baseline for the calculation of the 2010 TER. A larger improvement factor of 25% below the 2006 TER for all building types would be incorporated, resulting in an overall improvement factor ranging between 42.5%-46% relative to the 2002 notional. This approach would minimise changes to the framework already in place and provide the greatest certainty that the 25% target would be achieved. However, by requiring all buildings to achieve the same percentage reduction in emissions, this approach may not achieve the overall target of 25% in the most cost-effective way (DCLG 2010b).
- The Aggregate Approach: This option incorporates a new method for the calculation of the 2010 TER using a newly defined notional building based on a defined standard for the energy efficiency performance of each component of the building. Across each building sector, the approach defines an aggregate target of 25% lower emissions overall than under the 2006 Regulations. However, in considering the variability in the realistic level of emissions reduction achievable for various building types, the expected reduction from each (i.e. the contribution to the overall reduction target) is dependent on the cost of carbon mitigation required to achieve them. While this approach is considered to be a major procedural change, it provides a more cost cost-effective option and was therefore outlined as the Government's preferred options for the non-domestic sector (DCLG 2010b).

In considering the context of this research, it is important to examine the overall outcome of the consultation and assess the consequent developments introduced in the new regulations. This will determine the extent to which the issues highlighted within the context of the study were addressed in the new provisions.



### **9.3.2.1-Key Changes in Part L2A 2010**

The revised version of Part L 2010 and related documentation were initially scheduled for issue in October 2009 and were to be implemented by April 2010. The regulations were finally released at the end of April 2010 and are scheduled to come into effect in October 2010. The relevant developments outlined in the new document affecting the new non-domestic sector include the introduction of more stringent energy performance standards and a number of major procedural changes, which can be, summarised as follows (DCLG 2010a):

- *An aggregate approach to further CO<sub>2</sub> emissions reduction targets*

In line with the changes outlined in the consultation (DCLG 2009b), the new regulations included the major procedural change of adopting the aforementioned aggregate approach. The overall combined CO<sub>2</sub> emission reductions of the 2006 and 2010 regulations represent a 40% improvement over the 2002 requirements.

- *A new definition for the TER*

To enable the delivery of the target improvements through the aggregate approach, the TER has been redefined in an aim to relate specific improvement targets to what is actually achievable in the various non-domestic typologies. The TER is based on a building of the same size and shape as the actual building, constructed to a concurrent specification outlined in the recently issued 2010 NCM modelling guide. Developers are given the freedom to vary the specification, provided the same overall level of CO<sub>2</sub> emissions is (at least) achieved.

- *The extension of the scope of application of the regulations*

The scope of application has been expanded to include building extensions consisting of a conservatory or porch. Exemption from the energy efficiency provisions is only granted in specific circumstances where the existing walls, windows or doors are retained, or replaced if removed, and where the heating system of the building is not extended into the conservatory or porch.

- *A design-stage CO<sub>2</sub> emissions submission to building control*

In addition to the current requirement for CO<sub>2</sub> emission completion stage submission, a key requirement in the new regulations is the introduction of a new 'design-stage' CO<sub>2</sub> emission rate calculations and specifications submission to Building Control Bodies.

Some of these changes can be considered as very positive in terms of their potential to increase designer flexibility and encourage more involvement from building control early on in the design process. However at first glance, the introduction of the aggregate approach and new TER does seem to introduce an additional layer of complexity and uncertainty to the process. A considerable amount of effort will therefore be required to adequately understand these procedures.

### **9.3.2.2-Development of Software Tools for Part L 2010**

During the consultation process for the 2010 revisions, a consultation version of the default tool (cSBEM V1.0) was made available for use by consultees to investigate the implications of proposed changes (BRE 2009). While the consultation version of the domestic compliance calculation tool cSAP considered the introduction of a major development in the form of adopting a monthly calculation approach, cSBEM indicated that the quasi steady-state monthly heat balance approach would continue to be used. Furthermore, the cSBEM interface did not vary greatly from the current version of SBEM (V3.5).

An initial assessment of the official version of SBEM (V4.0) which was recently released for use with Part L2A 2010 (BRE 2010a), confirms the continued use of the same Microsoft Access-based data entry procedures. Beyond this, some of the key changes included in SBEM V4.0 include (DCLG 2009a; Anderson et al. 2009):

- Both the energy consumption (kWh/m<sup>2</sup> of building area) and CO<sub>2</sub> emissions of the building (kgCO<sub>2</sub>/m<sup>2</sup>) are calculated.
- Improvements to renewables with the addition of some new capabilities for modelling technologies in addition to the inclusion of an 'Energy Produced by Technology' calculation (kWh/m<sup>2</sup> of building area) in the BRUKL document.
- The use of rationalised building types and activities that map onto standard planning classes and merge several building types and some activity areas.
- Improved calculation of auxiliary energy for HVAC and improved lighting procedures.
- The integration of a solar overheating check. It is not clear at this point if this check is considered sufficient for requirements or if that a separate submission would be required.
- The format of the BRUKL document reflects the changes in the tool and includes some additional information.

The changes that have been introduced do enhance some aspects of the tool, especially with regard to the integration of the overheating check. This was one of the main issues that interview participants had prioritised (in section 7.4.8.2). In addition, there seems to be a marked improvement in the information provided in the BRUKL document, which is expected to increase its usefulness. However, some main issues that have not been dealt with include:

- No considerable improvements have been introduced to enhance the functionality of the interface.
- The limitations associated with the calculation engine and the quasi steady-state monthly heat balance approach have not been addressed.
- The options for modelling HVAC systems are still limited.

### **9.3.2.3-Future Revisions Beyond 2010**

The trajectory of the 2010 aims at the introduction of further improvements for future legislative revisions scheduled for 2013 and 2016. These are expected to continue the current trend in introducing more stringent energy performance standards to coincide with national and international targets. In addition, the re-cast of the EPBD (EPBD2) is likely to introduce further amendments and requirements (DCLG 2009c). Based on the findings of this research highlighting the current status of the industry skills gap, it is likely that the introduction of major procedural changes which require a significant shift or increase in industry resources (such as those included in the most recent 2010 revisions) will lead to challenges in implementation similar to those currently experienced with the 2006 amendments.

To avoid the reoccurrence of the challenges with each legislative revision, the implementation strategy should aim to minimise further major procedural changes in the upcoming revision of Part L (2013), scheduling them instead as a longer-term goal (e.g. in 2016). Ideally, a framework that aims to achieve targets through the introduction of incremental improvements to standards should instead be adopted, allowing sufficient time to incorporate measures to amend shortcomings in industry practices and remedy any issues that are likely to emerge in the implementation process.

Within the scope of the current 2010 revisions, there was an opportunity to particularly address the main shortcomings listed by interview participants such as the introduction of clear government policy where it is lacking to clarify issues such as the introduction of mandatory user accreditation and enforcement responsibilities.

## **9.4-Future Courses of Action Based on Research Findings**

The examination of the experience of applying the current legislative amendments outlined in this study has both highlighted the positive impacts of the amendments and the issues that have been experienced in its application. Further analysis of the associated contextual issues has sought to highlight the implications of the findings on achieving sectoral targets, the realisation of the objectives of the EPBD and the measured performance of buildings in use. Furthermore, the discussion of the changes that have been introduced in the most recent revisions has highlighted where these issues have either not been addressed or where there remains a need for the introduction of further measures.

Table 9.2 summarises the key recommendations that are proposed in each of these priority areas. A tentative assessment of the priority and practicality of their implementation based on a preliminary cost/benefit analysis for each is presented. The assumptions on which this preliminary assessment is based are further discussed in each of the relevant sections. A more

detailed analysis in the form of a more comprehensive Regulatory Impact Assessment must be undertaken to provide a more comprehensive study of the various options.

Table 9.2: Summary of key recommendations and cost/benefit analysis of implementation

Measures	Cost/benefit*
<b>Industry Skills Gap</b>	
• Uptake of training and unification of certification requirements	High/Medium
<b>Verification: A Competent Building Control System</b>	
• Mandatory pre-implementation training and certification scheme	High/Medium
<b>Energy Performance Prediction Tools</b>	
<b>Software Development</b>	
• Development of the default tool	Medium/High
• Extending the applicability of FI-SBEMs	Low/Medium
• Standardisation & simplification of input data requirements	Low/High
• Synchronisation of legislative revisions & software development cycle	Low/High
<b>Accreditation Process</b>	
• The development of more rigorous accreditation procedures	High/Medium
• Use of integrated software validation	Medium/Medium
• Improving consistency between software testing procedures & tool application	Medium/Medium
• Introduction of additional testing guidance	Medium/Medium
<b>Modelling Guidance</b>	
• The introduction of tool applicability guidance	Medium/Medium
• Comparative benchmarking	Medium/Medium

\*The cost benefit analysis is based on assumption that measures are implemented in the period covering the 2013 & 2016 revisions

#### 9.4.1-Industry Skills Gap: the Uptake of Training and Unified Certification

One of the main issues that has been highlighted in the implementation of the current amendments is the measurable industry skills gap, which will widen if further amendments are introduced without addressing the current shortcomings. The requirements of the 2010 revisions will require that the available workforce with skills in this area update their current skill sets with training on the use of new versions of software and the understanding of new procedural changes. Some possible measures in this field include:

Extensive training programs should be provided as early as possible in the implementation timescale to train the workforce to catch up with current amendments and increase the number of skilled specialists to accommodate the 2010 transition. In line with the mandatory training and certification schemes already in place for EPC assessors, a mandatory program should also be introduced to encourage the uptake of formal certification. Although mandating certification would ensure the universal uptake of training, this would incur very high costs that would have to be met in the short-term

More economically viable alternative approaches that could also increase the effectiveness of implementation include prioritising mandatory training for a representative proportion of employees in each practice. McElroy (2009) also advocates up-skilling through the use of

supported technology deployment. This involves the secondment of a team of specialists to undertake the required skills within organisations, with the ultimate goal of transferring those skills to internal staff. This approach can provide a short-term solution to addressing workforce requirements and can be effective in encouraging internal staff to adopt new technologies in an incremental, non-disruptive manner.

Although already extensively involved in providing training and continued education, the role of leading industry groups and professional engineering organisations such as CIBSE and IBPSA should be further expanded make best use of their expertise in the area.

#### **9.4.2-A Competent Building Control System: Mandatory Enforcement Training and Certification Schemes**

During the initial six months that followed the introduction of Part L 2006, Building Control Bodies were not adequately staffed with building control officers that were sufficiently trained in implementing the required procedures. In a survey of building control bodies, participants also reported a lack of legislative knowledge amongst clients and a significant percentage stated that additional technical guidance for Part L2A was needed (DCLG 2008a). While some improvements have been made on this front, some difficulties in enforcement still exist.

The 2010 revisions contain the introduction of provisions for a mandatory 'design-stage' CO<sub>2</sub> emission rate calculations and specifications submission to Building Control Bodies. This approach will engage building control from the early stages of the process and can positively impact the enforcement process. Successful implementation of this approach will require that an early response strategy of involving a wide-scale training program be adopted. This could be expanded to a mandatory pre-implementation training and certification program. As with any skills training program, this would incur high costs on the short run, however a significant increase in competency and, consequently, enforcement effectiveness is expected.

#### **9.4.3- Energy Performance Prediction Tools**

As part of the strategy to implement the performance-based approach, the government report 'Performance Testing of Buildings: BD 2535' assessed the various options considered for the potential expansion of the scope of pre-completion tests defined in the various Approved Documents of the Building Regulations (DCLG 2008d). The findings of the report highlighted both the limitations in the ability to introduce tests that were practically achievable in the pre-completion phase and, more importantly, a lack of market enthusiasm regarding further mandatory testing.

Consequently, beyond the current tests defined for compliance with the requirements of Part L2A (e.g. air-tightness and HVAC systems commissioning which both look at specific building

attributes), the NCM is therefore likely to continue as the standard for whole-building energy performance compliance demonstration.

The outcome of this research has in particular been to highlight the issues with the tool component of the methodology prompting further investigation in the field. Accordingly, an extended list of recommendations based on the overall findings is presented.

#### **9.4.3.1- Software Development**

One of the most positive outcomes associated with the introduction of the NCM has been the encouragement of the development of various commercial software tools to support its implementation. Over the past four years, the initial number of available accredited BEPP tools grew from three (in April 2006) to over 18 (in April 2010). To encourage the further development activities that will be required to address future amendments, development budgets should accommodate an allocation to meet compliance requirements (Lim 2009). Suggested recommendations aiming to further improve developments in this field are listed as follows:

##### **i-Further development of the default tool**

As the default calculation tool, SBEM has been a vital in the development of energy related building regulations in the UK and should therefore itself continue to develop. Efforts of the SBEM development team have largely focused on addressing the issues that arose during its use in an aim to ensure that it remained 'fit for purpose'. However, while various positive changes were incorporated into the newest version of SBEM (V4.0), some aspects are still lacking which warrants further efforts in this field.

Future directions should not only aim to make the default tool adequate but should aim to optimise it for the purposes of compliance checking. Various approaches that can be considered to achieve this include:

- The exploration of the feasibility of long-term program to extend the applicability of the default tool through the development of a more sophisticated calculation engine. Beyond the current quasi steady-state monthly heat balance approach, of the methods described in section 3.3.2, future developments in this field should consider the use of a simplified dynamic approach for implementing calculations. This approach has been successfully implemented in the development of the equivalent NCM default tool in France (Hitchin 2005) and will also allow for the continuation of the current strategy for encouraging market based development of tools by not directly competing with the commercial DSMs.
- The introduction of a graphical user interface for building data entry is perhaps the single most effective change that would increase the usability and applicability of SBEM. Potential variations to this option include the integration of a facility to allow the tool to export

building geometry to any of the widely available free online 3D viewers.

- Reviewing the standardised databases and systems to allow the more accurate modelling of energy efficient HVAC systems and technologies and-in line with suggestions for the SAP-the consideration of a wider scope of innovative LZC and passive strategies within the tool. Given the short development timescales, this option is potentially most achievable in the short-term.

## **ii-Extending the applicability of FI-SBEMS**

As a tool class, FI-SBEMS have seen the largest growth in the past year. In addition to their simplified format, FI-SBEMS often involve lower development costs and consequently lower user licensing/subscription fees relative to DSM class tools. In considering these factors, FI-SBEMS therefore provide an opportunity to increase the proliferation of tool use and subsequently, compliance checking at the earliest design stages.

This has to some extent occurred in the past two years, with an increased interest in integrating FI-SBEM compliance checking within various multi-function suites such as facilities management software. However as previously discussed, the technical scope of FI-SBEMS (specifically with regard to applicability to more complex building) remains limited by the SBEM calculation engine which they interface to. Future strategies should therefore aim to extend their capabilities to allow them to model more complex ventilation strategies, HVAC systems and energy efficient lighting systems through the integration of a calculation engine that employs the dynamic simulation modelling approach previously discussed.

There are currently several public domain DSMs such as EnergyPlus (US-DoE 2008) (which has recently been accredited for Hevacomp 8Vi) that could be used for this purpose without incurring a significant increase in software costs. However, as illustrated by the results produced by the DSM tools included in the comparative study discussed in Chapter 8, the possibility of variations arising from the different calculation algorithms will be an issue. This should be addressed through the introduction of measures such as more rigorous accreditation procedures.

## **iii-Standardisation and simplification of input data requirements**

Within an overall framework aiming to unify Part L2A calculation procedures to provide consistency of application, the use of standardised input methods and measurement conventions should be considered. A number of further measures that could be considered for implementation include a policy aiming to revise the use of problematic input requirements such as the  $\kappa$ m value. This would ensure the consistency and quality of input data, simplify the process and ensure the accountability of results.

#### **iv-Synchronisation of the legislative revision and software development cycles**

The current strategy of implementation adopted by the government has not sufficiently considered the coordination of the schedules of the regulatory and software development cycles. Relevant information should be made available as early on as possible to allow developers sufficient time to make the required changes to accredited BEPP tools and re-validate them. In the current regulations, key documents such as the NCM modelling guide (DCLG 2008g) were only made available well after the regulations had come into force resulting in a significant time lag. Plans have been put into place for the 2010 revisions to ensure that all relevant documents are made available well in advance.

#### **9.4.3.2-Software Validation and the Accreditation Process**

As an essential activity in software engineering (Bertolino 2007), testing can consume over 50% of the development costs (Beizer 1990). However, the lack of an adequate software-testing infrastructure is likely to have an even higher economic impact (NIST 2002). The establishment of BECSAS has in some ways aided in partially fulfilling the government's objectives by imposing a degree of regulatory pressure on software developers to conform to specific requirements regarding compliance tools (Lim 2009). However, as has been shown in the findings of the research, further improvements are required to upgrade the accreditation procedures currently in place. Consequently, the following measures are proposed:

##### **i-The development of more rigorous accreditation procedures**

Due to the very large number of variables and parameters involved in a typical tool, the testing of all possible permutations of the combinations of the parameters is not practically viable during the accreditation procedure of tools (e.g. Neymark & Judkoff 2002; Jensen 1995). It is, however, possible to increase confidence in results through the implementation of a well-documented and comprehensive validation methodology (Jensen 1995). Therefore, a viable and expeditious means to ensure that accredited BEPP tools are all unified to a specific standard that is deemed acceptable for legislative purposes is the development of a more rigorous approach to accreditation.

Current testing procedures aim to ensure that the calculations are technically robust, however as this study has shown, they do not seem rigorous enough to ensure that a sufficient degree of consistency in the modelling approaches used in the various accredited tools is achieved to ensure the consistency of compliance results. While the standardisation of modelling approaches might not be practically achievable (or desirable) in the more general scope of building energy simulation, for the particular purpose of compliance testing, consistency is essential in establishing 'fairness' of application.



Consequently, improvements should adopt a policy of upgrading the current accreditation procedures for all tool classes, while prioritising the revision of acceptable limits where significant inconsistencies in results have been found to bring DSM and FI-SBEM class software into closer alignment. In adopting this policy, the current accreditation scheme should be in a position to ensure that BEPP tools continue to conform to the imminent changes required by future developments in the EPBD (Lim 2009).

## **ii-Improving the consistency between software testing procedures and tool application**

In the accreditation requirements for DSM class tools, some of the test cases described in the TM33 procedure used in the first stage of the accreditation process require that they be carried out using prescribed simplified steady-state assumptions (e.g. for surface heat transfer coefficients). However, DSMs are in practice used with their default algorithms, where some tools may calculate more appropriate time-varying coefficients (CIBSE 2006).

This issue is recognised in the CIBSE TM33 documentation and guidance on more detailed testing procedures is outlined. It is imperative that this be considered a priority in the development of future accreditation procedures to ensure that the consistency of the algorithms used in the testing procedure for DSMs and those used in practice is maintained (Strachan et al 2006). It is also important that the end-users of the software be made more aware of these circumstances.

## **iii-Use of integrated software validation**

A potentially useful approach that could be applied as a complimentary measure to the validation of tools during the accreditation process is the facilitation of continuous embedded validation through the use of integrated testing. This method has been frequently used in component-based software engineering to ensure that various software units continue to function in compliance with system requirements, in effect creating 'self-testing software' (Denaro et al. 2003).

While various studies examining the embedding of validation testing within building energy prediction tools have been carried out (e.g. Strachan et al. 2006; Ben-Nakhi & Aasem 2003; Lomas et al. 1997), its widespread use for this purpose has yet to be realised. However, its potential usefulness in further establishing the credibility required of BEPP tools used in the context of regulatory compliance may well provide the suitable platform by which to achieve this.

As an additional/complementary measure to the initial accreditation tests, the use of integrated testing could be undertaken using the theoretical framework of the 'user-friendly validation module' (VLD) first suggested by Ben-Nakhi and Aasem (2003) and implemented within ESP-r. This work was further expanded with the use of ASHRAE Standard 140-2004 and European CEN standards validation tests (Strachan et al 2006), which points to the high possibility in applying

the approach using established testing procedures.

In practice, the implementation of embedded validation for accredited software would entail the establishment of a pre-defined set of common tests (or the use of pre-existing standards), the development of a set of analytical solutions by which to compare results to and the development of an integration framework for pre-existing tools.

Whilst considerable initial development time may be required, this approach will potentially offer various benefits in the long-term. By allowing potential users to confirm the accuracy of the tool, user confidence in the specific abilities of the accredited tools and also the credibility of thermal modelling in general will be enhanced (Lomas et al 1997). In addition, this approach can also potentially encourage both developers and professional users to undertake frequent assessment and validation to examine and control the accuracy of generated results and ensure that they continue to be within specified tolerance bands required for compliance with regulations.

#### **iv-Introduction of additional testing guidance**

Additional measures that ensure that procedural guidance is followed not only in terms of the calculation and reporting processes, but also in terms of a consistent modelling approach should be introduced. These guidelines could also include the development and publishing of a wider set of empirically based data to provide benchmarks that can be used to more thoroughly test the accuracy of individual algorithms (Lomas et al 1997).

### **9.4.3.3-Modelling Guidance**

#### **i-The introduction of tool applicability guidance**

While several measures such as providing adequate training, support and supervision may improve user quality (Hensen 2008), users must also be provided with adequate guidance to ensure correct application. Documents such as the 'Non-Domestic Heating, Cooling and Ventilation Compliance Guide' (DCLG 2006b) that sets out minimum provisions for HVAC and DHW systems for compliance with Part L2A are currently available. However, further guidance to clarify the specific capabilities and limitations of accredited tools with regard to various building types, scales and HVAC configurations should also be provided to advise potential users as to the suitability of tools to their specific modelling requirements.

#### **ii-Developments in benchmarking**

As an element of an integrated design process, benchmarking can play an important role in improving the energy performance of buildings. A survey conducted in the USA showed that the use of benchmarking was already widespread, with 73% of respondents confirming that they used some sort of energy benchmarking process (Mills et al. 2008).

In the context of compliance demonstration, the provision of additional guidance through benchmarking can provide a valuable tool in aiding the compliance process and increasing the validity of results. The development of relevant benchmarks in this case is therefore of particular importance. It is suggested that a set of benchmarks regarding typical projected CO<sub>2</sub> emissions or energy consumption values for various building/HVAC combination types be developed. This can be used in the following ways:

- As comparative benchmarking to aid in confirming the validity of the generated results for proposed designs against comparable designs.
- In a more in-depth approach, as action-oriented benchmarking that can be used to enable modellers to identify potential energy-efficiency options and prioritise areas for more detailed analysis and full-scale audits (Mills et al. 2008).

**Chapter Summary:**

- The analysis of data was undertaken through the application of triangulation techniques.
- The main findings synthesised from this study have highlighted general shortcomings in each of the three parameters defined to assess the experience of applying the methodology.
- The suitability (fitness for purpose) of tools in particular has been the main barrier to the overall application of the approach.
- The implications of the shortcomings highlighted in this research will extend to such areas as achieving the sectoral carbon targets, the realisation of the objectives of the EPBD and the effect on the actual energy performance of buildings that have gone through the compliance process.
- Changes included in the 2010 revisions have introduced positive aspects such as increased designer flexibility and involvement of building control. However, the aggregate approach introduces an additional layer of complexity and uncertainty.
- Useful changes introduced in the version of SBEM developed for the 2010 revisions include the integration of the overheating check. However, the main issues that were highlighted in previous versions were not dealt with.
- Since building energy legislation is subject to a cyclic review process, the findings of the current amendments can be extended to informing future revisions, and accordingly recommendations that address the issues highlighted are proposed.

## Chapter 10: Conclusions of the Research

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*This chapter presents the conclusions of the research based on the analysis of the main findings outlined in the previous chapter. Future work arising out of this thesis pertaining to the continued impact of the approach to applying Part L 2006 as well as in the more general context is proposed. The original contribution to knowledge of this research and its practical applications through dissemination are discussed.*

### **10.1-Conclusions of the Research**

This research has sought to assess the viability and applicability of the use of modelling-based BEPP tools for the demonstration of compliance in performance-based regulations, in the specific context of the experience of introducing the National Calculation Methodology (NCM) for Approved Document Part L2A of the UK Building Regulations 2006 (England and Wales).

With regard to the specific objectives of the study, the findings of the research support the conclusion that the use of energy performance prediction has the potential to allow the exploration of innovative approaches to achieving performance requirements. However, due to the shortcomings in the establishment of the required industry capability to implement the approach and the considerable predictive variability between BEPP tools demonstrated here and reported in other studies, considerable efforts are still required to extend the usefulness of energy performance prediction from design decision support into its use as a credible legislative support tool for performance-based regulations.

It is important to acknowledge that the challenges experienced in implementation were in part due to the novelty of the approach and the magnitude of change that was required from industry over the relatively short period allowed. However, given the history of challenges experienced in the development of performance-based regulations for the domestic sector (in particular the lessons learnt from introduction of the SAP for compliance demonstration for the 1995 Building Regulations), substantial knowledge concerning expected issues for the non-domestic sector was available. This should have been used in informing the development of the non-domestic regulations and in the establishment of adequate measures to mitigate the challenges that were experienced in the introduction of the NCM.

To summarise, the main challenges and positive aspects associated with this approach are listed below.

***Challenges and Issues:***

In assessing the factors that have impeded the realisation of the full potential of this approach various challenges have been highlighted, the main issues can be listed as:

- The combined findings of the longitudinal industry survey and in-depth interviews have provided an indication of gap in current industry skills, the shortcomings of adaptation approach adopted by industry and the inconsistent implementation and enforcement strategies employed.
- The results of tool study highlight three important issues; a large degree of predictive variability between the compliance benchmarks produced by accredited tools, the lack of consistency in granting approval (a pass/fail result) for the same building and limitations in the scope of applicability of accredited tools. These issues are not adequately addressed in the tool accreditation process currently in place.

As outlined in the recommendations of the research, a number of relatively simple initiatives can be undertaken in the short term to quickly address some of most prominent issues.

***Positive Aspects:***

Various positive aspects associated with the introduction of the approach have occurred. These include:

- The amendments have been a key factor in raising the profile of energy legislation and are expected to continue doing so with the introduction of ever more stringent requirements. Further positive impacts can be expected if more integration between Part L and other sustainability targets ( e.g. BREEAM ratings or further renewables requirements) is achieved.
- Occupational specialisation has led to the expansion of the core group of highly skilled experts in the field. The introduction of the amendments has also been a driving force in affecting changes on the organisational scale and there has been a noticeable change in the operational strategies of many organisations that have encouraged the consideration of energy performance compliance from the earlier stages.
- There has been an increase in market-based driven development of energy performance prediction tools.

In relating the findings of this research to the new 2010 revisions, it can be assumed that despite some potentially very positive changes that were introduced, the additional layer of complexity and uncertainty associated with yet another approach of applying the methodology is expected to lead to similar issues as those experienced in the 2006 amendments.

Finally, in considering the wider scope of the energy performance agenda, the findings and conclusions of this research provide additional evidence that confirms the view that in the absence of legal implications, non-professional practices regarding energy efficiency continue to exist across the profession and the construction industry as a whole (Mason 2004).

## 10.2-Recommendations for Future Work

With regard to future research beyond the issues discussed in this thesis, a number of gaps in existing knowledge have been identified. In continuation of further research within the scope of the Part L2A 2006 amendments, a body of further work is planned to extend the investigation. These aim to assess the continued impact of the shortcomings identified in this study with regard to the contextual issues that have been discussed in section (9.3.1). In addition, there is an opportunity to extend some of the proposed topics to the more general area of building energy performance. Specifically, research in the following areas must continue:

### 10.2.1-Measured Performance of Part L2A Compliant Buildings

A key contextual issue explored in the analysis of the data in Chapter 9 was the impact of the findings concerning the predictive variability of tools on the actual or 'measured' performance of buildings. Key work undertaken by Olivier (2001) has highlighted the large discrepancies between the expected targets of previous Part L amendments 1982, 1990 and 1995 and the actual delivered improvements measured in the domestic sector.

In further exploring this issue for the Part L2A 2006, a case study based evaluation of buildings that have been constructed since the introduction of the current amendments is proposed. This study would aim to:

- Assess if the regulations have resulted in actual improvements compared to similar buildings constructed within the timeframe of the 2002 regulations.
- Compare the energy performance in use and quantify the actual improvements.
- Investigate the degree of variability between the actual emissions and those predicted in the compliance document.

Various approaches may be adopted in the implementation of this study, the following of which are proposed:

- **Field study approach:** A post-occupancy evaluation of buildings that have been constructed and are fully operational to determine the variability between the as 'as-built' calculation and the actual performance. Potential sources of data include metered information to record actual energy consumption, which can be augmented through the installation of data loggers to measure and monitor environmental variables (Brown & Wright 2006).

- **Desk study approach:** A comparison of EPC (asset) ratings with DEC (operational) ratings of a random sample of buildings constructed within the relevant timeframe. This data is publically available for the non-domestic sector through the Non-Domestic Energy Performance Certificate Register - 'The Landmark Database' (DCLG 2010).

### 10.2.2-The Assessment of Tool Accreditation Procedures

A key recommendation of this research has been the development of more rigorous accreditation procedures and the investigation of the potential of using embedded testing. Since it has been acknowledged that the current CIBSE TM33 procedures used for the accreditation of DSMs in particular are an ongoing effort, further studies to explore the potential options to upgrade the standardised tests provide an important opportunity for further research. The main aims of this work include:

- The assessment of the credibility of current assessment procedures.
- The identification of gaps in current testing procedures.
- The provision of a realistic framework for more effective validation.

The work proposed involves the assessment of current accreditation procedures through the following methods:

- A review of available software validation procedures to identify gaps in the tests used in the BECSAS testing process.
- The comparison of results produced by selected tools accredited under the current BECSAS scheme with results produced by tools validated through established mechanisms such as BESTEST.

### 10.2.3-The Viability of Accredited Tools

As identified in the tool study, despite the existence of various studies that discuss the factors contributing to the variability found in the general field of energy performance prediction tools, very little information with regard to the more specific issues that affect the viability of accredited compliance tools in the UK exists. Accordingly, this suggests that various studies in this particular area would be valuable in informing future policy decisions regarding the development of adequate tools. Suggested topics within this area include:

- A sensitivity analysis of compliance tools to determine the effect of changes in key input variables on generated results for accredited compliance.
- The investigation of user influenced variability on compliance results.
- The assessment of quality control mechanisms and the potential for the introduction of a standardised QA procedure.

#### 10.2.4-An Optimised Compliance Demonstration Tool

This study has identified a significant scope for research into the development of an optimised tool for compliance demonstration and has discussed various options for implementation, which include:

- The integration of a more 'sophisticated' calculation engine.
- The introduction of a graphical user interface for building data entry / integration of a 3D geometry export facility.
- The development of more representative standardised databases and systems.

Research in this area can be divided into a number of deliverables, implemented over both short and long-term time frames. The following format is proposed:

- **Preliminary stage:** A more thorough analysis of the costs and relative impacts associated with each option will be required to assess the feasibility of each and prioritise them accordingly.
- **Development Stage:** The development of a prototype tool using the approach considered to be most effective. This could be undertaken as a collaborative project with a software development company/research institute.
- **Test Stage:** Evaluate the tool in use to assess applicability.

As outlined in section 2.4.1, as the implementation of performance-based regulations becomes more widespread, it will require the increased use of performance assessment. The outcomes of this research area can therefore be usefully extended to serve as a prototype for the development of optimised compliance tools for markets beyond the UK.

#### 10.2.5-Impact Assessment of Future Courses of Action

In section 9.4, some key recommendations based on the findings of this research were presented. A tentative assessment of the priority and practicality of the implementation (a preliminary cost/benefit analysis) of each was presented in Table 9.2. A more detailed analysis in the form of a Regulatory Impact Assessment (RIA) is therefore proposed to present a comprehensive study of the feasibility of the various options for addressing the issues that were highlighted in this research. The key areas of investigation proposed for this study are:

- Mandatory training/certification
- Software development and accreditation
- Development of modelling guidance material
- Development of benchmarks

A study of this nature would require extensive resources and would therefore be ideally implemented as a collaborative undertaking with various parties and stakeholders in the UK. Some preliminary work has already been conducted in this area and would provide a basis on which to proceed (e.g. DCLG 2008a; DCLG 2007a; DCLG 2007b).



### 10.3-Contribution to Knowledge and Limitations

This work has presented an assessment of the application of a legislative approach to the integration of modelling in the design process associated with the steady shift from prescriptive to performance-based standards. In achieving the main research aim, the study has made the following original contributions to knowledge in the field:

- The study has provided a detailed and comprehensive ‘snapshot’ of the adaptive capability of the UK construction industry through the analysis of firsthand feedback from practitioners involved in the implementation of the new regulatory requirements.
- An integrated analysis of implementation and enforcement dynamics in this context was presented and has provided a framework for prioritisation of issues for future amendments.
- A comprehensive assessment of available accredited BEPP tools was carried out and has provided confirmation of issues that have been previously reported but have not been the subject of rigorous investigation.
- The research has led to the development of a framework by which to assess the success of the approach.
- Beyond the scope of the current amendment, the findings of this research have led to the formulation of a number of recommendations for consideration in future legislative amendments.

The limitations outlined in section (1.3) identified the ‘practical’ scope of the study. However, the applicability of the research has extended beyond the scope defined. As outlined in section (9.3.2.2), the consultation version of the domestic compliance calculation tool cSAP considered the adoption of a monthly calculation approach, findings from this research regarding the tool suitability, were directly used to inform a government advisory group consulting on this issue. This is discussed as part of the dissemination activities outlined in section (10.4).

Additionally, in considering the cycle of legislative reviews, the nature of the assessment-which was necessarily retrospective-was identified in section (1.3). However, the main findings of the research have been shown to be of continued value and importance. These extend the applicability of this research by serving both as a case by which to compare the developments included in the new 2010 revisions and a basis by which to inform future regulatory amendments through the formulation of the recommendations outlined in section (9.4).

#### **10.4-Dissemination Activities**

Within the academic community, the findings of this study have been discussed through the publication of peer-reviewed academic articles in addition to a number of peer-reviewed conference papers, scientific conference presentations and posters (see list of Publications and Key Presentations). Further publications arising from this thesis include a proposed journal article discussing the full findings and recommendations of the study outlined in Chapters 9 and 10.

As a research project that seeks to contribute to the application of policy initiative in the context of industry, dissemination of results beyond the realm of academic publications is an important issue that was considered from the initial phases of the study. Consequently, the findings of the research have been presented on a number of platforms.

- Policy development: The main findings of the study have been presented at a government chief scientist meeting and a policy formulation meeting for a government advisory group consulting on future developments for calculation tools in the context of the domestic sector.
- Industry collaboration feedback: As a reflection of the collaborative nature of the research and in recognition of the significant role of industry professionals in several phases of the research, dissemination activities in the form of continual feedback have taken place throughout the study. Results have been shared within industry in the form of a summary of findings that was made available to industry professionals who participated in the interviews. Furthermore, a final set of guidelines based on the aforementioned proposed journal article will be formulated and produced in a technical report format. This will be distributed using the participant contact database upon the completion of the research.
- Continual Professional Development programs: On a wider scale, the findings of this research have been incorporated as part of a CPD seminar program offered by leading UK professional organisations and included presentations given at both regional and national events.
- Software development feedback: Findings of the comparative analysis of accredited tools discussed in Chapter 8 were shared with the various companies in the form of a development team meeting presentation; this facilitated a platform for the discussion of potential improvements for their software.

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*Volume 2: Appendices*

**Performance Based Regulations:  
The Viability of the Modelling Approach as a Methodology  
for Building Energy Compliance Demonstration**

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## Appendix A: Industry Survey Questions

### 1-First Survey Questions

Please answer all the following questions. Any information you provide will be treated with the utmost confidentiality.

#### Part 1: Basic Information (Questions 1-6 of 30)

##### 1- What is your profession? (Please select only one option)

- a. Building Engineer
- b. Designer/Architect
- c. Energy/Environmental Consultant
- d. Building Physicist
- e. Other (Please specify)

##### 2- How many years of experience have you had in your occupation? (Please fill in)

	Year(s)
--	---------

##### 3- What is your organisations main activity? (Please select all applicable fields)

- a. Design/Architectural Services
- b. Building/Services Engineer
- c. Environmental/Energy Consultants
- d. Other (Please specify)

##### 4- What is the estimated organisation size? (Please fill in)

	Employee(s)
--	-------------

##### 5- What is the estimated project value range? (Please select only one option)

- a. Below 0.5 Million GBP
- b. 0.5 to 1 Million GBP
- c. 1 Million to 2.5 Million GBP
- d. 2.5 Million to 5 Million GBP
- e. Above 5 Million GBP

##### 6- Which of the following project types does your organisation most frequently undertake? (Please select all applicable fields)

- a. Residential
- b. Commercial (e.g. Retail/Office)
- c. Cultural (e.g. Museum/Library)
- d. Healthcare
- e. Educational
- f. Other (Please specify)

#### Part 2: Computer Usage Information (Questions 7-11 of 30)

##### 7- Which of the following construction related software applications do you most frequently use? (Please select only one option)

- a. 2D CAD Software
- b. 3D CAD Software
- c. Architectural Visualisation/3D Modelling Software
- d. Lighting Software
- e. Energy Modelling Software
- f. CFD Applications
- g. Structural Design Applications
- h. Project Management Applications
- i. Other (Please specify)

**8- Which of the following construction related software applications are most frequently used in your organisation? (Please select only one option)**

- a. 2D CAD Software
- b. 3D CAD Software
- c. Architectural Visualisation/3D Modelling Software
- d. Lighting Software
- e. Energy Modelling
- f. CFD Applications
- g. Structural Design Applications
- h. Project Management Applications
- i. Other (Please specify)

**9- What is the percentage of construction related software users in your organisation?(Please fill in)**

	Percent
--	---------

**10- Please rate the frequency of use of construction related software in your organisation during each of the following phases of the design/construction process.**

	Always Used	Frequently Used	Occasionally Used	Never Used
Pre-design/Programming				
Schematic Design				
Design Development				
Construction Documents				
Construction & Commissioning				
Post Occupancy Evaluation				

**11- Please rank the following factors in terms of their importance in the selection of software applications for use in your organisation (1=highest, 7=lowest).**

	1	2	3	4	5	6	7
Financial Affordability							
Ease of Use							
Availability							
Technical Support							
Required Use							
Reliability/Stability							
Plausibility of Results							

### Part 3: Energy Performance Prediction Methods & Tools (Questions 12-22 of 30)

#### a-Methods

**12- In which of the following fields does your organisation employ performance prediction methods? (Please select all applicable fields)**

- a. Heating & Cooling Applications
- b. Lighting Applications
- c. Ventilation & Air Quality Applications
- d. Building & Room Acoustics
- e. Fire Safety
- f. Other (Please specify)

**13- In your opinion, please rank the following energy performance prediction methods according to the factors stated below (1=highest, 4=lowest).**

	Frequency of Use				Reliability of Results				Ease of Use			
	1	2	3	4	1	2	3	4	1	2	3	4
Engineering Experience												
Rules of Thumb												
Design Guidelines												
Computer Based Energy Simulation												



**b-Tools**

- 14- In addition to meeting regulatory requirements, rank each of the following factors according to their degree of importance in the decision to use BEPP tools in your organisation (1=highest, 4=lowest).**

	1	2	3	4
To sustain market competitiveness				
To accelerate the design process				
To improve design quality/minimise design risk				
To improve environmental standards				

- 15- Are there any additional factors that contribute to why your organisation employs BEPP tools?**

a. No

b. Yes-Please specify contributing factor(s):

- 16- Please rate the frequency of use of BEPP tools for energy prediction tasks during each of the following phases of the design/construction process.**

	Always Used	Frequently Used	Occasionally Used	Never Used
Pre-design/ Programming				
Schematic Design				
Design Development				
Construction Documents				
Construction & Commissioning				
Post Occupancy Evaluation				

- 17- For computer-based energy simulation, which of the following BEPP tools are used for energy performance prediction? (Please select all applicable)**

- a. SBEM
- b. Tas
- c. IES
- d. ESP
- e. EnergyPlus
- f. In-House Developed Tool
- g. Other (Please specify)

- 18- Please rate the following factors in terms of their importance in the selection of specific BEPP tools for use in your organisation (1= highest, 7=lowest).**

	1	2	3	4	5	6	7
Financial Affordability							
Ease of Use							
Availability							
Technical Support							
Required Use							
Reliability/Stability							
Plausibility of Results							

**c-Use and Training**

- 19- For projects undertaken by your organisation, who is usually responsible for energy prediction tasks? (Please select all applicable fields)**

- a. Project Designers/Architects
- b. Building Services Engineers
- c. In-House Simulation Group/Department
- d. External Consultant
- e. Other (Please specify)

- 20- How were you trained to use BEPP tools? (Please select all applicable fields)**

- a. Self Taught
- b. Peer/Colleague
- c. Internal Training Course(s)
- d. External Training Course(s)

- e. Other (Please specify)

**21- How many years of experience have you had in using BEPP tools?**

	Year(s)
--	---------

**22- What is the estimated percentage of BEPP tool users in your organisation? (Please fill in)**

	Percent
--	---------

**Part 4: Part L Compliance (Questions 23-29 of 30)**

**23- Which of the following methods did you previously most frequently use for Part L2A compliance demonstration? (Please select only one option)**

- a. Elemental Method
- b. Whole-Building Method
- c. Carbon Emissions Calculations Method

**24- In addition to demonstrating building regulations compliance, for which of the following purposes do you use BEPP tools? (Please select all applicable fields)**

- a. Improving Overall Energy Performance
- b. Estimating & Minimising Overheating
- c. Producing Client Reports
- d. Research Purposes
- e. No Other Purposes
- f. Other (Please specify)

**25- Which of the following BEPP tools are you using or intend to use for Part L2A compliance? (Please select all applicable)**

- a. SBEM
- b. Tas
- c. IES
- d. ESP
- e. EnergyPlus
- f. In-House Developed Tool
- g. Other (Please specify)

**26- Has the introduction of the new Part L (effective April 2006) affected the choice of BEPP software?**

- a. No

- b. Yes-Please specify new tool:

Please specify reason(s) for change:


**27- Which of the following methods do you use to validate output from (energy) simulation exercises? (Please select all applicable fields)**

- a. No output validation
- b. Multiple self check
- c. Multiple user re-check
- d. Personal experience
- e. Other (Please specify)

**28- Which of the following methods are used to provide information and training concerning changes to Part L2A and the application of the National Calculation Method (NCM) in your organisation? (Please select all applicable fields)**

- a. Official/Government documentation
- b. Commercial media sources (e.g. software company websites)
- c. Internal seminars/courses/briefings
- d. External seminars/courses/briefings
- e. None
- f. Other (Please specify)

29- In your opinion, please rate your initial experience with using the National Calculation Method (NCM) as a compliance methodology for Part L2A in terms of the following factors:

	Very Good	Good	Satisfactory	Unsatisfactory
Clarity: Is it clear and direct in its methodology?				
Usability: Is it easy to use?				
Validity: Can it be considered as an adequate measure of overall energy efficiency?				
Flexibility: Does it provide a more flexible approach to compliance demonstration?				
Efficiency: How does it rate in terms of the task time?				
Reliability: Does it give correct results?				

**Further Research**

30- Thank you for participating in the survey. If you are interested in taking part in further research, the results of which will be shared with you, please fill in the following information:

Name:	
Job Title:	
Company:	
Telephone:	
Fax:	
email:	

## 2-Second Survey Questions

Please answer all the following questions. Any information you provide will be treated with the utmost confidentiality.

### Part 1: Basic Information (Questions 1-6 of 30)

#### 1- What is your profession? (Please select only one option)

- a. Building Engineer
- b. Designer/Architect
- c. Energy Consultant
- d. Building Physicist
- e. Other (Please Specify)

#### 2- What is your organisation's main activity?

- a. Design/Architectural Services
- b. Building/Services Engineering
- c. Environmental/Energy Consultants
- d. Multi-disciplinary
- e. Other (Please Specify)

#### 3- What is the estimated organisation size? (Please fill in)

	Employee(s)
--	-------------

#### 4- Which of the following project types does your organisation most frequently undertake? (Please select all applicable fields)

- a. Residential
- b. Commercial (e.g. Retail/Office)
- c. Civic (e.g. Museum/Library)
- d. Educational
- e. Healthcare
- f. Other (Please specify)

#### 5- For projects undertaken by your organisation, who is usually responsible for Part L2A Compliance Calculations? (Please select all applicable fields)

- a. Project Designers/Architects
- b. Building Services Engineers
- c. In-House Simulation Group/Department
- d. Out-sourced/ External Consultant
- e. Other (Please Specify)

#### 6- Prior to the introduction of the new building regulations and the National Calculation Methodology (NCM), which of the following methods did you most frequently use for Part L2A energy compliance? (Please select only one field)

- a. Elemental Method
- b. Whole Building Method
- c. Carbon Emissions Calculations Method

#### 7- How do you rate your experience in using the National Calculation Methodology (NCM), in terms of the following factors:

	Very Good	Good	Satisfactory	Unsatisfactory
Clarity: Is it clear and direct in its methodology?				
Usability: Is it easy to use?				
Validity: Can it be considered as an adequate measure of overall energy efficiency?				
Flexibility: Does it provide a more flexible approach to compliance demonstration?				
Efficiency: How does it rate in terms of the task time?				
Reliability: Does it give correct results?				

8- Have you encountered any difficulties in using the National Calculation Methodology (NCM)?

a. No

b. Yes(Please specify)

9- How do you rate the importance of the following factors in your selection of tool name for Part L2A energy compliance calculations:

	Very Important	Important	Less Important	Not Important
Financial Affordability				
Ease of Use				
Availability of Technical Support				
Reliability/Stability of Tool				
Plausibility of Results				
Modelling Capability				

10- Have any other factors contributed to its selection?

a. No

b. Yes(Please specify)

11- How many projects have you worked on using tool name for Part L2A energy compliance calculations?

	Projects
--	----------

12- In practice, how do you rate tool name in terms of the following factors?

	Very Good	Good	Satisfactory	Unsatisfactory
Data Input Procedure				
Modelling Capability				
Plausibility of Results				
Overall task time				
Interoperability of Software				
Availability of Technical Support				

13- Have you encountered any difficulties in using tool name for Part L2A energy compliance calculations?

a. No

b. Yes(Please specify)

14- Which of the following methods do you use to validate compliance calculation output from tool name? (Please select all applicable fields)

- a. No output validation
- b. Manual calculation
- c. Multiple self check
- d. Multiple user re-check
- e. Other (Please Specify)

15- In addition to Part L2A compliance, for which of the following purposes do you use (tool name)? (Please select all applicable fields)

- a. Improving Overall Energy Performance
- b. Estimating & Minimising Overheating
- c. Producing Client Reports
- d. Research Purposes
- e. Producing Energy Performance Certificates
- f. None
- g. Other (Please Specify)

16- Have you used any of the following tools for Part L2A calculations?(Please select all applicable fields)

- a. No
- b. SBEM (iSBEM)
- c. IES Virtual Environment
- d. EDSL Tas
- e. Carbon Checker
- f. Hevacomp
- g. Other (Please Specify)

**17- Did you find there to be a significant difference in results than those produced by tool name?**

- a. No
- b. Yes(Please specify)

**18- Which tool did you find to give the most favourable results with regard to achieving Part L2A compliance?**

- a. SBEM (iSBEM)
- b. IES Virtual Environment
- c. EDSL Tas
- d. Carbon Checker
- e. Hevacomp
- f. Other (Please Specify)

**19- Have you used any of the following tools for other applications?**

- a. SBEM (iSBEM)
- b. IES Virtual Environment
- c. EDSL Tas
- d. Carbon Checker
- e. Hevacomp
- f. Other (Please Specify)

**20- How were you trained to use (tool name)? (Please select all applicable)**

- a. Self-Taught
- b. Peer/Colleague
- c. Internal Training Course
- d. External Training Course
- e. Other (Please Specify)

**21- Which of the following certification programs have you participated in? (Please select all applicable)**

- a. None
- b. BRE Competent Persons Scheme
- c. CIBSE Low Carbon Consultant Program
- d. Other (Please Specify)

**22- How do you rate the effectiveness and adequacy of this training?**

- a. Very Good
- b. Good
- c. Satisfactory
- d. Unsatisfactory

**23- Please outline any other issues you have encountered in using tool name:**

**24- Thank you for participating in the survey. If you are interested in taking part in further research, the results of which will be shared with you, please fill in the following information:**

Name:	
Job Title:	
Company:	
Telephone:	
Fax:	
email:	

## Appendix B: Summary of Tool Issues from Survey Responses

For the purposes of this section tools other than SBEM have been anonymised as follows:

- The two DSM class tools will be identified as Tool A and Tool B.
- The FI-SBEM tools accredited at the time will be identified as Tool C and D.

### Calculation Tool (SBEM):

Problems encountered with SBEM mainly concerned the difficulty and confusion arising from data entry via the non-graphical tab-based form, which was considered too time consuming. SBEM was reported to be slow, had limited HVAC options and applicability limitations with respect to building types with high ventilation rates (e.g. - laboratories). The following issues were also reported:

- **Modelling errors and inconsistencies:** Difficulties in passing specific strategies (e.g. gas heated natural ventilation); modelling low energy systems (e.g. adiabatic cooling and ground source heat pumps) and problems with glazing, loads and lighting were experienced.
- **Software errors and compatibility:** Some software bugs and issues with system-crashing were reported.
- **Results validity:** Inflexibility in options, questionable default calculation assumptions and a lack of clarity undermined confidence in results.

### Commercial Dynamic Simulation Modelling Software (DSM Class):

Even though a graphical user interface for modelling and data entry is provided for both DSM tools, users reported a lack of satisfaction due to their relative crudeness and limited import/export capabilities. With regard to the specific tools, the following concerns were reported:

- **Data entry procedures:** For Tool A, the geometry creation module had stability issues with complex models. For Tool B, a primitive 2D drawing interface and the lack of a 3D model import facility were the main concerns.
- **Software errors and compatibility:** While the multi-functional structure of Tool A was generally regarded as favourable, users reported a number of problems associated with the limitations of the individual modules. Overall, the tool had interoperability, backwards compatibility issues and a tendency to crash frequently.
- **Technical support and training:** In the case of Tool A, respondents reported that a significantly longer period of instruction were required, however the training program did not give practical or realistic examples of how certain building systems should be set up. In

some instances, technical support staff were unable to answer queries and provided conflicting advice

- **Modelling errors and inconsistencies:** For Tool A, the program tends to miscalculate heating energy consumption, lighting energy consumption and ground floor U-values. Certain energy efficient technologies were lacking and difficulties in passing low energy buildings were experienced. For Tool B, users reported that it could not solve specific HVAC strategies and new versions coped poorly with inter zone air movement
- **NCM Compatibility:** For Tool A, the unavailability of specific SBEM related parameters was reported (they have since become available). The definition of HVAC systems was considered to be difficult, did not reflect in the notional building as in SBEM and was not clearly reported in the BRUKL document.
- **Results validity:** Users of Tool reported large results variability between different tool versions and some respondents considered it to be the easiest to manipulate to get favourable results. Even though Tool B was considered reliable, there was concern with regard to the Part L2A calculation method.

#### **Commercial Interfaces (FI-SBEM Class):**

Despite the limitations of the SBEM-based calculation engine, a significantly lower number of issues were reported compared to SBEM and the DSM class software.

- **Data entry procedures:** Issues between the interface of Tool C and AutoCAD and with importing drawings from client models have been experienced.
- **NCM Compatibility:** For Tool D, the ability to define various methods of heating and cooling are limited and for larger buildings the calculation engine can take a while to produce the results.



## Appendix C: Interview Schedules

### 1-Industry Practitioner Interview Schedule

#### Section One - Introduction and Pre-interview Set-up:

1. Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?
2. What were the main design criteria that were considered in this project?
3. Did you have certain sustainability targets?

#### Section Two: Key topic = Tool

4. Which software did you use for this exercise?
5. Why was this tool chosen? (Were there any influencing factors-financial...etc?)
6. How would you rate your proficiency and experience in using this tool (prior experience, training....etc)
7. Would you have preferred to use another tool?
  - 7.b (If Yes) Why would you have preferred this other tool?

#### Section Three: Key topic = Process

8. Could you briefly describe the process that was involved with achieving Part L2A Compliance for your project?

#### Subtopic = Application

9. How were the different roles and responsibilities for each of the group members structured?
10. At which stage of the design process was the Part L2A compliance (simulation) exercise undertaken?
11. Did you require any form, if any, of co-operation or help from other specialists?

#### Subtopic = Timescales

12. In your opinion, was this the appropriate time to undertake the simulation exercise?
  - 12.b (If No) At which stage would you have preferred to undertake this and why?
13. How much time (in man hours) was approximately spent on the simulation exercise in total?
14. How did this vary from the time you initially planned to spend?

#### Subtopic = Input Parameters

15. Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?
16. If not, what kind of measures did you use to achieve compliance? (Design changes or input parameters)
17. Did this involve changing or altering the input parameters?
  - 17.b (If Yes) Which input parameters did you alter?
  - 17.c Which Input parameters did you observe as having the most affect on your results?
  - 17.d Describe (approximately) the variability in results that was observed.
18. How did these results feedback back into informing the building design process? (or was it separate?)

#### Subtopic = Results Validity and Quality Control

19. Are you formally accredited to carry out Part L2A compliance calculations?
  - 19.b If not, what route will you follow to submit you work?
20. Did you use any internal methods to assure quality control and the validity of your results?
  - 20.b (If Yes) Please describe these methods
21. Did your building pass with regard to the requirements of building control
22. Did any of your team have any contact or interaction with Building Control?
  - 22.b (If Yes) Please describe this interaction (how, when, method, impact)

#### Subtopic = Issues In Application

23. What are the main issues, if any, did you encounter during the simulation process?
  - 23.b (If yes) Please describe these issues.
24. Which would you regard as the main priority for consideration in future Part L2A revisions.
25. How would you recommend that these issues be dealt with?
26. In summary, how would you assess the overall procedure and how do you see it being improved?

## 2-Building Control Body Interview Schedule

### Section One: Introduction and Pre-interview Set-up:

1. Could you please give a brief description of the range of projects do you deal with?
2. On projects you have worked on, please describe the scope of your role and responsibilities.

### Section Two: Key Topic=Methodology

3. What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006? (increase in workload, costs...etc)
4. Did you receive any training with regard to the new technical requirements of the Part L2A amendments?
  - 4.b (If yes) please describe (method, duration, effectiveness...etc)
  - 4.c. (If no) please describe alternative source of information.
5. What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?
6. From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance? (expand to simulation tools)

### Section Three: Key Topic = Application

#### Subtopic=Process

7. At which stage of the design process does your involvement usually begin?
8. Do you think involvement at this stage is effective in ensuring Part L2A compliance?
  - 8.b (If not) At which stage would you prefer this to occur?
9. Please describe the impact of your involvement on the development of projects.
10. Who is your usual point of contact on projects? (architect, contractor, client....etc)
11. Do you view this to be the ideal person to interface with?
  - 11.b (If not) who would you prefer, and why?
12. Are they the person responsible for the Part L2A compliance simulation/calculation work?
13. Which calculation tools/ methods are most frequently used to carry out this work?
14. With regard to Part L2A compliance, what kind of information do you require to be submitted? (e.g. modelling assumptions, HVAC systems..etc.)

#### Subtopic = Compliance and Quality Control

15. Do you require that they submitting the Part L2A work be certified under either of the accreditation schemes?
  - 15.b (If no) How do you gauge their competency?
16. Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route? (e.g. for overheating)
17. What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?

#### Subtopic = Role of Building Control

18. In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?
19. What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?

#### Subtopic = Issues and Future Developments

20. What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance?
21. What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision? (i.e.-structural changes to the system, changes to the roles and responsibilities of key players...etc) and how would you recommend that these be dealt with?
22. How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period)

23. In summary, how would you assess the overall procedure and how do you see it being improved?

## Appendix D: Interview Transcripts

### 1-Industry Practitioner Interview Transcripts

Table A-D.1 outlines the details of the interviews. For each interview, an assigned interview code formed by a letter *I* (which stands for *interview*), as well as the number representative of the order in which the interview took place (e.g., I01 for the first interview) were used to differentiate between the interviews and maintain participant anonymity.

Table A-D.1: Industry interviews

	Organisational Role	Job Description	Qualifications	Experience
I01	Senior Environmental Analyst	Environmental Analysis	BSc. MPhil.	N/A
I02	Environmental Engineer	N/A	BSc. Engineering/ CIBSE LCC	4 Years
I03	Sustainability Director	N/A	FIPHE/CIBSE LCC	N/A
I04	Associate Director	Environmental Engineer	BA (Arch) MSc MCIBSE CENG/ BRE CP	6 Years
I05	Senior Engineer	Building Physicist	MSc	4 Years
I06	Associate	Building Simulation Consultant	BSc. Physics MSc. Energy	19 Years
I07	Energy Consultant	N/A	MEng (Hons) AMMechE.	5 Years
I08*	Engineer	N/A	MSc. Physics	2.5 Years
I09*	Engineer	N/A	MSc. MSci	2.5 Years
I10*	Engineer	N/A	M Eng	4 Years
I11*	M & E Engineer	Building Simulation Consultant	M Eng	5 Years
I12	Principal Consultant	SBEM CPS/EPC Scheme Technical Manager	PhD. BSc. DIC CCHEM CENG	20 Years
I13	Member	Chartered Engineer	C Eng	25 Years
I14	Mechanical Engineer	Sustainability Specialist	BRE CP CIBSE LCC/BREEAM CSH. BSc. Mech Eng.	3 Years
I15	Sustainability Specialist	Sustainability Specialist	MSc (Environmental/Energy) LCC BREEAM	2 Years

\* In these interviews, a more senior member of staff (I0\*) with a supervisory role was also in attendance and offered some additional insights.

## Interview 01 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion?**

I01: The project I thought we could review is a high school mechanically ventilated. 2, maybe two storeys, science labs and a lecture theatre and, I don't know how much detail you want for this.

**IN: Maybe if you could give me an idea of the approximate location, which region of the UK it located in.**

5 I01: It was in Coventry.

**IN: Coventry, ok. And when was this work undertaken?**

I01: A year ago, maybe.

**IN: A year ago, ok. What were the main design criteria that were considered for this project?**

10 I01: Normally we would have liked to have used natural ventilation, but because of location, the proximity to a busy road they were concerned that we wouldn't be able to meet the noise criteria and therefore they wanted sealed windows.

**IN: Ok, did you have a certain sustainability targets or agenda?**

I01: Supposedly, yes. But in reality, if it passed Part L, I think everybody would be happy.

**IN: Which software did you use for this exercise?**

15 I01: We used Tas.

**IN: Which version?**

I01: 9.0.c or d possibly, I can't remember

**IN: Why was this tool chosen?**

20 I01: It was the only software that was available. Or do you want to know why was it the only software available?

**IN: Was that because of financial reasons or was it because it was the software you'd been using?**

25 I01: It's quite complicated actually, in the previous company I'd been working with. , originally we used IES, but for various reasons, we, IES were unable, unwilling to deal with us. I really don't want to go into that, but for various reasons we ended up having to use Tas because at the time, it was the only alternative to IES that was available.

**IN: So you were required to use a DTM?**

I01: Oh, I see. Yes, you're right. We could have used SBEM. , the general feeling is SBEM is not up to the job of doing anything that's- complicated buildings. It's ok for simple geometry.

30 **IN: How would you rate your proficiency and experience in using this tool in terms of prior experience, formal training....etc?**

I01: I suppose you could ask that on a scale of 1 to 10 or something, don't know, maybe. It's a really hard question to answer. Look at it this way, training, I mean I've been on the training course for using the basic Tas modelling program and the Part L course. Both of which were 2 or 3 day courses, I think. So have (I been on training), maybe.

35 **IN: So how long had you been using it?**

I01: I started using Tas in, well, I started using it well in anger in summer-literally-in summer of 2005. So it would have been just two years when I did this work.

**IN: Would you have preferred to use another tool?**

40 I01: Well based on my fairly limited experience using the other tools, it's hard to say. , I can't really answer that question.

**IN: Could you briefly describe the process that was involved with achieving Part L2A Compliance for your project?**

45 I01: The team I was working with was like the internal sustainability group, sustainability and building analysis group. So we didn't deal directly with the clients on this. , I was kind of reporting to the M & E project director or whoever was running the project within our company. So I got the instructions from him to prepare the Tas model and perform the Part L analysis. So perhaps, (it was a bit more standard, sustainable) design in house.

**IN: How were the different roles and responsibilities for each of the group members structured?**

50 I01: It was just me doing the building and the modelling, doing that part. And the information was obtained by walking across the office to the divisional director's desk and saying 'hey can I have this and this and this and who should I contact for these drawings' and then I probably got the information to contact the architects for the drawings and then talked to the in-house MEP team to work out the MEP systems, flow-rates and things like that.

**IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**

55 I01: Took it fairly early on, I think it was the, round about stage D. Because they were really interested in getting a preliminary idea of what their, whether it would achieve compliance and what their likely running costs would be. And the Part L compliance was something I was reasonably happy to do, but to try and extrapolate running costs from a Part L model, I had a great (time) trying to tell people that I really didn't want to do this and they really shouldn't allow these results whatsoever. It was quiet hard to get that point across.

60 **IN: Did you require any form, if any, of co-operation or help from other specialists?**

I01: In terms of getting information?

**IN: In terms of getting information, how you actually implemented the exercise.**

65 I01: The information would have come from the architects and the MEP group. Architects obviously externally and MEP within the company. As far as help with the modelling was concerned, I probably referred to the Tas telephone support from time to time. Obviously would. And probably if there were requests of odds and ends questions about Tas, there was one other guy within the company who had a fair bit of experience. So, if there was anything I wasn't sure about, I'd go to him.

**IN: And this was information regarding Tas rather than Part L?**

70 I01: How to do Part L calculation in Tas. So it was less about the modelling and more about what would be the appropriate assumptions, or ways to do it. I don't know if it's something you get onto in a subsequent question.

**IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**

75 I01: It wasn't, no. Because the design, the building wasn't, the design hadn't been finished so it was much too early to say whether the building as it ends up would've passed Part L or not. On the other hand, you do a preliminary Part L calculation to get an idea of whether you're in the right ballpark to pass. So, yes and no.

**IN: At which stage would you have preferred to undertake this and why?**

I01: When the building was bit more designed. When things like services systems had been finalised. Then really only once you get to that stage can you say whether if you think the building will or will not pass Part L.

80 **IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**

I01: This is like asking me to fill in my timesheet about 12 months down the line. It was a long time because the information came in from the architects in drips and drabs. So we'd be able to build, lay out the floor plan then go back and get the information on the windows, then go back and get information on the building fabric. Because the information didn't come in a complete package, it took 3 times as long to build. It was a long process. In terms of numbers of days, I can't really give you an answer.

**IN: When you initially started this, how long did you approximate it would take?**

85 I01: Probably much shorter than it actually took. To something like that I would have maybe said about a week to do the initial modelling and another week to do the Part L calculations. I would have said two weeks. Going back from that, in all it maybe took about 5 weeks. That's a guess, maybe. And bearing in mind that I wasn't working solidly on that project, but had it sort of mixed in with other things.

**IN: Was the building able to achieve compliance from the initial run?**

90 I01: Not sure if the initial run actually produced any sensible results. If you mean the initial run. Once it was working, once the model was working, did it comply? You know, I can't remember, I have a feeling that it probably didn't.

95 **IN: If not, what measures did you use to achieve compliance later on?**

I01: In Tas, the Part L calculations are split between preparing the model and then defining the systems. I'm pretty sure that any changes that actually resulted in it passing would be on the systems side and not on the model side. So I think the model is less, there's less variability in the modelling, and (the variability) isn't in putting the model together, there's uncertainty there, but that less than when it comes to choosing the systems and making some huge assumptions about what systems go into the building.

100 **IN: Did this involve changing or altering the input parameters?**

I01: Yes

**IN: Which input parameters did you alter?**

105 I01: I remember that a lot of the classrooms were serviced by a constant air vole system, so some of the changes in terms of air supply set points, temperature set points, air vole flow rates and possibly operational hours would have had have been fiddled around with.

**IN: Which Input parameters did you observe as having the most affect on your results?**

I01: Certainly choice of system and the re-assignment of specific system to specific rooms is going to make an enormous difference. So if you decide that you are going to treat your staff rooms with fan coils and not with a

- constant air vole system, in that sense the choice of system is going to make a big difference.
- IN: Describe (approximately) the variability in results that was observed.**
- I01: Probably at least 20% in terms of the actual Part L target percentage.
- IN: Were you then able to inform the systems design?**
- I01: I don't believe so.
- IN: So it was separate from the actual design process?**
- I01: Yes, in many ways it's a good example of how not to do the Part L study.
- IN: Are you formally accredited to carry out Part L2A compliance calculations?**
- I01: What do you think? No. I'm not.
- IN: If not, what route did you follow to submit your work?**
- I01: Somebody in the company would have had to sign that on if it were going externally out the company as a report or something, somebody who was accredited to do such studies would have had to have signed it off.
- IN: Did you use any internal methods to assure quality control and the validity of your results?**
- I01: At the time, no. It was quite a useful exercise because it actually flagged up quite a number of instances where a kind of QA system would have been very useful and it kind of (got us thinking) about developing a QA system for building simulation and analysis. Although, at the time we didn't have anything like that in place.
- IN: Did your building pass with regard to the requirements of building control.**
- I01: You know what? We got kicked off the job, so I have no idea. It wasn't about anything to do with the Part L analysis, that was alright.
- IN: Did any of your team have any contact or interaction with Building Control?**
- I01: No. No. Had we been doing a proper formal Part L submission, I imagine we would have had to talk to building control, but that would have been at a later stage if we were doing it.
- IN: What are the main issues, if any, did you encounter during the simulation process with regard to the compliance methodology and the software?**
- I01: The recurring issue is the compliance methodology is, seems to be open to interpretation when you've got buildings and systems that don't really match an existing definition. There are things that you can't do in the simulation model which you may be doing in your actual design building. For example having extract ventilation systems that draw air from treated zones. That air will be coming through at the temperature it leaves the treated zone, obviously. In the Tas model, I believe its assed to be drawn in from somewhere without really taking into account where its coming from. So they don't do the right kind of calculations, things like that. So there's maybe difficulties in defining actually how your systems feed into other different zones. Is that a problem with the methodology or is it a problem with the software? Software claims to follow the methodology, so it might be a problem with the methodology, but on the other hand, maybe the checks for software compliance are not stringent enough and they should be more detailed. , there are a number of different issues, I think. It has issues, yes.
- IN: Which would you regard as the main priority for consideration in future Part L2A revisions.**
- I01: I'm not sure whether the software accreditation process is sufficiently rigorous for Part L and it seems to be based on, there's a CIBSE technical, TM32 or something like that, which is sort of standard tests for software. It seems to be just based on that. Doesn't really reflect what you're trying to do with Part L.
- IN: Other than TM33, the methodology for software accreditation?**
- I01: It may be useful to look at buildings that have gone through the Part L process. Actually look at , look at something that's been built and (informed in its systems) by using those kinds of (regulations) and see whether, well, whether really it's as good as it should be and whether people have just tweaked values and changed a few things to get it to pass. I'm not sure whether the building as built is going to be the same as the building that was modelled for Part L. I suspect not, but only when sufficient time has allowed to have buildings that have gone through the process actually built and then go look at them and check. So some sort of audit process for the Part L and maybe that's what, that's what EPBD, the certificates, EPCs that kind of thing, perhaps that, then someone to compare the performance as built with the performance as designed. But I don't know how relevant that is to the actual Part L process or whether Part L interacts with that.
- IN: How would you recommend that the (stated issues) be dealt with?**
- I01: That's just it, looking at buildings that have gone through the Part L process and finding out whether they're actually performing as predicted and if they're not, why not? Is it because the design was changed or were they, I mean it's really difficult to. I think for the last part of this questionnaire you want to ask the question 'how can you make Part L better?'

165 **IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

170 I01: It's not very constructive to say I don't think it's very good then and then turn around and say I don't really know how it can be improved. That's pretty what I have to say, if I'm being honest. It could be, maybe if I'd done more final Part L submissions; I'd be in a better position to answer that. Because the Part L work I've done is, almost exclusively been very early on, sort of indicative Part L results, rather than having the pressure of sort of 'you've got to do these results, you got to submit it to building control and get it through'. So it was all done a bit sketchily.



## Interview 02 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?**

I02: It's a retail project we were working on in Reading. It's a large superstore.

**IN: What kind of systems did you use for the buildings?**

5 I02: It's a heated and cooled system with VAV systems, and bookstore heaters and also fan coils in staff areas.

**IN: What were the main design criteria that were considered in this project?**

I02: We had to put wind turbines up for planning permission and also a CHP. We also looked into tri-generation of the CHP as well, and also energy efficient lighting.

**IN: Did you have certain sustainability targets?**

10 I02: We had to meet 10% carbon savings from the CHP.

**IN: Which software did you use for this exercise?**

I02: We used IES

**IN: Why was this tool chosen? (Were there any influencing factors-financial...etc?)**

15 I02: We use IES within the company. We do have the SBEM and the iSBEM, but we just find that it takes too long to input the data.

**IN: With SBEM?**

I02: We, oh no we used the DSM method for it, the dynamic simulation with IES.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training....etc)**

20 I02: I've been using it for around 2 years now. I've passed the accreditation exam for it. But, I mean there's a lot of bugs still in the software, so it's still continuing to learn it all.

**IN: So you've had formal training?**

I02: Yes.

**IN: Would you have preferred to use another tool?**

25 I02: Not really. I don't think there's much, many other ones on the market. There is Tas, but we can use IES for other simulations as well, and not just for Part L compliance.

**IN: Could you briefly describe the process that was involved with achieving Part L2A Compliance for your project?**

30 I02: Initially, we did a calculation on a basic layout from the architects. Because it's like a chain of stores, we used initial default data from what we already know goes into other stores. We ran the calculation and checked that it passed the calculation. The main problem with that was trying to choose the exact types of systems going in because they weren't clearly matched using SBEM, so that's why we started going round the dynamic simulation route because you've got more flexibility and control of the systems. So we ran the project, it passed, which was fine and finally when it was built we went back, visited the site, checked that everything was installed and put in more information with the proper manufacturers efficiencies.

35 **IN: How were the different roles and responsibilities for each of the group members structured?**

I02: The architect provided us with all the information and the drawings and for the U-Values. We did the design in-house, so we got the information-the electronic and the mechanical information- from in-house. The renewables as well, we did the design for it and then we fed back into the group about the progress which we had for it.

40 **IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**

I02: It was probably the, initially, it was right at the start of the project

**IN: So it was an indicative sort of study first?**

I02: Yes, just a basic one. Then we did one at halfway the process and one at the end.

45 **IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**

I02: We got information from the architects, we got information from the CHP manufacturer as well for it.

**IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**

50 I02: I think so. Because we've done it before for other projects right at the end. When we've been asked to do it by the architects we've had problems with it not gaining compliance. So, it's definitely important to do it at the start.

**IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**

I02: Depending. On this project, because it was quite a large project we probably spent around 4 days for each part of the simulation. Probably all together 12 days. That's for the initial and the final one.

**IN: How did this vary from the time you initially planned to spend?**

- 55 I02: It was a bit longer because we had the issue of not being able to choose the exact equipment, so we had to go and get, send it across to building control to check that they were happy with the assumptions for it. So we ended up having an extra days meeting.
- IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**
- 60 I02: Yes.
- IN: So you didn't have to change any input parameters or anything to achieve compliance later on?**
- I02: No, luckily. Because we find it a lot easier for buildings which are heated and cooled to gain compliance. The problems we have is with naturally ventilated buildings, and then we have to look into lowering the lux levels of the areas or maybe putting in a type of renewable energy source.
- 65 **IN: Which Input parameters did you observe as having the most affect on your results?**
- I02: We always find it's either the lighting, if that's high to start with, or the efficiencies and the specific fan power. Those are the main inputs.
- IN: Are those associated with this building type in particular or just general building types?**
- I02: Just general
- 70 **IN: Describe (approximately) the variability in results that was observed (in percentage).**
- I02: We can get say a 10-15% change in the CO2 output by editing the lighting
- IN: 10-15% reduction?**
- I02: It can be. Yes.
- IN: How did these results feedback back into informing the building design process? (or was it separate?)**
- 75 I02: We issued an initial draft report and sent that out to the client and to the architect. They were happy then with the design.
- IN: Are you formally accredited to carry out Part L2A compliance calculations?**
- I02: Yes, with CIBSE.
- IN: You're a Low Carbon Consultant?**
- 80 I02: A Low Carbon Consultant.
- IN: What route did you follow to submit you work?**
- I02: What do you mean by?
- IN: The work was submitted on your behalf as a Low Carbon Consultant?**
- I02: Yes, it was submitted through the architect to the building control authority.
- 85 **IN: And you were named as the person on it?**
- I02: Yes, we send the form off with a copy of our certificate to prove that we're accredited to do so.
- IN: Did you use any internal methods to assure quality control and the validity of your results?**
- I02: Yes, we have a QA process in the company anyway. So it falls into that.
- IN: Please describe these methods**
- 90 I02: Ok, initially we've just got a process to run a step by step instruction about what information we need to gather. It's sent down with the draft report, we get a job number out for it. At the same time a quality test, there's 2 people who's accredited to do it, so the other person will then check it and then it'll go and run again and then we'll file it properly after its been issued.
- IN: Did your building pass with regard to the requirements of building control**
- 95 I02: Yes
- IN: Did any of your team have any contact or interaction with Building Control?**
- I02: We did, because it was the first project we had with that client and we couldn't get the systems to match, the HVAC systems to match. So we had an initial, I think it was a half a day meeting with building control, because we were going to do a lot of projects with client to make sure that they were happy with all the assumptions we were making.
- 100 **IN: Please describe this interaction**
- I02: This is quite near the start of the design process. It was a meeting at the offices here.
- IN: How did this impact the process for you?**
- 105 I02: It made it a lot easier, because they were happy with the assumptions we made rather than issuing the report and then them coming back to us and saying we don't understand why you've chosen this type of equipment. So it made it flow a lot easier and now we have a standard for each project done for this client. We know exactly what to put in.
- IN: What are the main issues, if any, did you encounter during the simulation process?**
- I02: As in terms of the software?

- 110 **IN: Everything. Software, process, difficulties you had in understanding legislation.**  
 I02: The main problem we have is with the software. The software which we were using a year ago with IES was filled with lots of bugs, so we kept getting crashing on the simulation. Our BRUKL document would not show values which we actually put it, so we had lots of problems just running the calculations and making sure everything we put in was what was coming out. So it was going through our learning stage of how to use
- 115 the software properly.  
**IN: Which version of the software did you initially use?**  
 I02: I think it must have been 5.4 or something like that around 2 years ago.  
**IN: And the last one?**  
 I02: This ones, 5.8.2. But every time they upgrade the software it seems to be a lot better now. The other main
- 120 problems we have, is not with this project, with other projects is trying to get people involved in it at an early stage with the SBEM. If it doesn't gain compliance, it's trying to talk to the architects and talk to the different people and the like the electrical and the mechanical and say 'no you've got to choose more efficient boilers, you've got to choose this', and sometimes they can just say no our design's fine, you need to change something else. It's the hardest part we have with it.
- 125 **IN: So you had no problems in basically understanding the requirements of the methodology or legislation?**  
 I02: Not really. I went on. When I started at the company, I went on an initial course to learn about Part L documents. We've got good contacts with building control officers as well, with different areas. So they're quite good at explaining if they want something certain done. If you've got any questions to ask, we normally
- 130 call them.  
**IN: Which would you regard as the main priority for consideration in future Part L2A revisions. How would you recommend that these issues be dealt with?**  
 I02: I think the main problem at the moment is all the different software(s) give off different results. I think they need to sort out a way that all the different software(s) are similar with each other, because you can run
- 135 different things on different versions and you can get completely different results out of it. If we run something with the dynamic simulation model or an SBEM model, in one way, in one type of software it might pass and in another one it might fail. So I think they need to get the software sorted out before they go further.
- IN: In summary, how would you assess the overall procedure and how do you see it being improved?**  
 I02: I think the main problem at the moment is lack of understanding on some clients' parts or on some peoples' parts. They don't really understand the process and they find out right at the end an SBEM calculation is required and then panic. And the building, because it hasn't been designed in that way normally fails. So you have to go back and retrofit it. So I think when it was coming out, I think it should have been a lot more messages coming out to like architects, to clients just to say this is what's happening and to get the
- 145 process involved right at the start.  
**IN: Do you have any other comments, any issues, any else you'd like to talk about?**  
 I02: Not really. I think they just need to clean up the process. I think it's becoming more aware now because of the energy performance certificates.

### Interview 03 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?**

I03: The best would be this one, which is our head office. Built in 2007. Timber frame, concrete, hollow rib floors and engineering brick externals.

5 **IN: And with regard to systems?**

I03: Ground source heat pumps. Ground source heat pumps, solar thermal hot water and we've also got air source hot water. We've also got Mitsubishi PQFY refrigerant water heat pumps which feed the air handling unit. We've got ground air fresh air intakes and we preheat the air, what else have we got, PV, intelligent power, daylighting, daylight sensing, daylight dimming, external lighting dimming, deep window reveals, narrow plan offices. They only thing I haven't done, being perfectly honest, is natural ventilation.

**IN: Natural ventilation?**

I03: The reason being was we were more concerned about natural ventilation working and control and didn't think, well we almost knew that there would be big arguments about whether the window was open/shut.

**IN: And this is mainly an office building then?**

15 I03: Yes, it is. So it's our corporate headquarters.

**IN: What were the main design criteria that were considered in this project?**

I03: It had to have a pragmatic sustainable design and it had to be sensible. Obviously, accommodate the amount of people we needed to with space for extension. Be in the area that it's in, because it's on our existing land and also to achieve a BREAM excellent, which was fairly fundamental.

20 **IN: So that was the sustainability target?**

I03: Yes.

**IN: Which software did you use for this exercise?**

I03: This is quite interesting actually. SBEM, Tas and IES. You're frowning now. There is a reason. We also used CYMAP. And what we found-and I'll let you have the data. We used SBEM obviously for Part L, we used, originally we used Tas for solar modelling. So we employed a consultant purely to use Tas to show us where light would be within the building at any one time, so that we could design the solar shading out front. We then went down the road of ground source heat pumps and to get the warranties from the ground source heat pump contractor, they needed to carry out a thermal model to model the building loads and the ground source, but used IES. So we ended up using all of them. The interesting thing was though that the dynamic simulation models are far in excess better than the non-dynamic, i.e. the CYMAP. Because effectively what we were finding is our building services contractor, who was allowed to design the project, was using CYMAP and the figures that they were coming out with for overall loads of plant were way above the dynamic models. Because all they were effectively doing was taking the worst case on the worst day in the worst rooms and adding it all up. Whereas the dynamic model takes into account that not every single room in the building will be at its worst case on the worst day and the worst solar gains, literally, so it was quite interesting.

**IN: Why was this tool chosen?**

I03: Because we could do it ourselves. That's the honest answer.

**IN: How would you rate your proficiency and experience in using this tool?**

I03: Because I do it myself, absolutely brilliant. Yes, I'm ok. I have difficulty with what they call some of the services. Here you can't for example put in a ground source heat pump system with a VRF system, which creates problems. And I don't think that comes up with the right results necessarily, because I think our results should be better because for the entire building's heating and cooling system, it's looking at a VRF system which its assuming is an air source system.

**IN: So how long had you been using it before you modelled this building?**

45 I03: Since inception. Which would have been 2006, wouldn't it?

**IN: Would you have preferred to use another tool?**

I03: No. Do you want the reason? I, because we do SBEMs infrequently. We do them for every job, but we probably have 15 jobs on the pitch at any one go, so we're not continually always doing SBEMs. It's part of the job function, but it's not the only part of the job. If we were to use something like Tas or IES, which is a lot more complex, then it's the sort of thing you'd need to be doing every day. And we'd probably forget how to do half of it between the times that we'd need to do models. Which is why we use SBEM, plus it's free.

**IN: Could you briefly describe the process that was involved with achieving Part L2A Compliance for your project?**

I03: Yeah, fairly standard really I suppose. We tend to use outside building control officers, so approved

55 inspectors, rather than local building control. And the reason we do that is you can normally engage them earlier to help you actually design the project in terms of Part L compliance and what have you. But overall, the responsibility was mine to ensure that the building did comply, which with the sort of things we'd thrown at it in terms of sustainability, I don't think there were any problems at all.

**IN: How were the different roles and responsibilities for each of the group members structured?**

60 I03: The way that we like to do it is we'll keep control of the SBEM calc, etc., but insist that the different parties provide us with the relevant information. So for example, I will get the U-Values off of the architect. I won't make them up myself or use defaults, or wherever possible I won't use defaults. And the same for building services...etc. So we will get the designers to tell us what the coefficients of performance are...etc, etc. But we're fairly strict in we like to keep control over the SBEM because it's that important. Because if we don't  
65 pass, we don't pass code, we don't get to building control, we don't get completion certificates and that's general for all ourselves.

**IN: All your projects?**

I03: Yes.

**IN: At which stage of the design process was the Part L compliance simulation exercise undertaken?**

70 I03: Very early. It was done almost in conjunction with the specification. Bearing in mind we were the client, contractor, designer and everything on the job. I actually wrote the services spec and at the same time did the initial SBEM calc for the building. And again one of the things we're finding with BREAM is that they've completely changed the weightings with the new 2008 version and they've really honed in on energy. So the 15 credits for energy that was based on CO<sub>2</sub> emission, is now based on EPC rating. So to be able to understand  
75 what you're going to get with a BREAM excellent or whatever with the 2008 version, you are going to have to do the SBEM calc a lot earlier.

**IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**

I03: Yes, architect mainly for the U-Values.

80 **IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**

I03: Yes.

**IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**

I03: You reckon a week.

**IN: 1 week, full days?**

85 I03: Yes, it's normally, well if you were doing it full on with no other interruptions than anything else you'd get it. A building of this nature you'd do in two. And when I did, I checked it again with the new EPC software and did it from scratch again and that took two days. In general, a building of this size which is 3000 odd square meters takes that sort of time.

**IN: How did this vary from the time you initially planned to spend?**

90 I03: We knew how long it would take

**IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**

I03: Yes

**IN: Did you change any measures to make sure that it achieved compliance?**

95 I03: No, we did play around with it to see what effects different things would have.

**IN: So you changed or altered input parameters?**

I03: Yes, things like air volume, air leakage, U-Values, and sort of used it a bit more like a design tool to say whether it's worth doing things. For example, you know whether it was worth beefing up the walls, was it worth beefing up the roof in terms of U-Values...etc., etc. We sort of used it a bit more than most would  
100 normally have used it.

**IN: Which Input parameters did you observe as having the most affect on your results?**

I03: Services, without a doubt

**IN: Describe approximately the variability in results that was observed in percentage.**

105 I03: Lighting was huge. And I'm still not convinced about the lighting at all. If I was being lazy and purely went for defaults, so I could have just easily gone through the whole building and said it most of it was all T5 lights or compact fluorescents but the final design hasn't been carried out yet, I would have got a far better score than actually putting in the actual wattage per lux or what have you. And the simple reason for that is because you have to have, you can't just dot light fittings where you like, because if you've got a 600x600 grid you need to put them in a half sensible grid, which means that the number of light fittings and the wattage

110 may be higher than the calculation tool expects to see for that particular item. And I think that's wrong actually. I'm still not convinced about the lighting control either.

**IN: So what was the percentage variability you saw by changing that?**

I03: I can't remember to be honest. But it was fairly, you know, fairly significant. It would have been, in terms of a fair amount of CO<sub>2</sub> per meter squared. I wouldn't like to say how much.

115 **IN: How did these results feedback back into informing the building design process?**

I03: We had regular design meetings and to be fair the architect we used were fairly good sustainability-wise and they were keen to say 'what if we did this, what if we did that' and most of it helped write the specification in terms of 'this is how we'll do it, this is what we'll do'. One of the things that I don't think people bear in mind is air tightness in design. They do when they come to actually test the building and this building wasn't the easiest to test and I think if we'd have been able to go back to the design, if we had been brutally honest, we would've bolted some of the details to make it easier to test.

**IN: Are you formally accredited to carry out Part L2A compliance calculations?**

I03: Yes

**IN: What route did you follow to submit your work?**

125 I03: The, I worked through the BRE

**IN: And when you submitted the work to building control, it was submitted on your behalf?**

I03: No I submitted to building control.

**IN: So you were the person named?**

I03: What tends to happen is I submit to building control and once a year a get a glorious little email come from the BRE which I just dread which says can I complete all the calculations that I've done and send it back to them.

**IN: Did you use any internal methods to assure quality control and the validity of your results?**

I03: In terms of SBEM?

**IN: In terms of, yes.**

135 I03: No not really, other than the calculation itself, it varies. I'm the only accredited assessor, although I've got other people who know how to use the tools, so they'll input things like geometry and things for me, but there's no formal assessment checks as such.

**IN: Did your building pass with regard to the requirements of building control**

I03: Yes

140 **IN: Did any of your team have any contact or interaction with Building Control?**

I03: Oh yes we did throughout, they almost formed part of the team and they were engaged very early on. So they were engaged at design stage, not only for Part L, but for fire escape, etc.

**IN: Please describe this interaction.**

I03: It varies, half formally, half informally. So they'd be invited to design meetings. We'd have specific building control meetings to make sure we were ticking all the items. They'd be invited to inspect work, to make sure of the duct work testing...etc. Whether they do or not turn up is up to them. But nine times out of ten it's informal, it's 'what if we did this, what about that' and at the end we just package everything up and give them all the certificates at the end.

**IN: And how did this interaction impact the design process?**

150 I03: It helped, without a doubt. It's something we do as a matter of course, so we don't see it as being anything out of the ordinary. We've got 3 or 4 approved inspectors that we use on a regular basis. They know what we want, we know what they want. And it tends to work quite well.

**IN: What are the main issues, if any, did you encounter during the simulation process?**

I03: During the actual simulation process?

155 **IN: Please give me the whole list.**

I03: I suppose the biggest bug there is the time it takes. And finding, because it's complicated its finding the time to spend two days out of the office effectively, because I normally do them at home, where you're not being interrupted and where you can just literally get on and plug the information in. What we were lucky with I suppose here is that the building footprint was fairly well fixed and the building hasn't changed drastically. On other buildings what is a complete nightmare is if people start changing the building fabric, because what we find is because the envelopes are that complicated it's very difficult, once you start omitting one thing and changing something else you really lose track of what you've done. So you're actually better off to just abort whatever calculation you've done previously and do another calc, which isn't very helpful. So revisions and things like that are difficult.

165 The other bit that I had to speak to the BRE about was how we determined the type of building services systems we've got here, because they're that new, I don't, I think we've been penalised. Because you can't link a ground source heat pump system with a VRF system at the moment in SBEM. And I'm not sure that even the BRE understand that. And I would like some way of being able to alter and play around with bits that obviously are far better, for example the ground source heat pumps are better than an air cooled system. I know that, but I'm not convinced that that's been reflected in the SBEM calc.

**IN: So you've had a number of issues with the software?**

170 I03: Yes. I also had issues with the latest software because, and this is possibly because I couldn't be bothered to read the instructions, like any man. We sort of play with it first and realise it doesn't work. But when you then out it in EPC mode, you actually have to add the, a digit into the unique reference number, otherwise it won't calculate. And I think that that's a little naughty and it did create a few problems, because we'd been doing 2 or 3 calculations and until we'd gotten an answer back from the BRE as to why it was crashing the calculation, I wasn't sure of doing SBEM calcs with the same tool. So that worried me a little bit.

**IN: Any other issues with the software?**

180 I03: I think those are the major ones. The, it is the time it takes. Other than that, I mean, the general information they could make it easier to input information so you can just tab through, but you can't. You know you go from one tab which is (at) the top of the screen, tab again on it, it goes to the bottom. You go to the postcode and back to the address. It could be sort of more professionally, and I think some of the print outs could be improved.

**IN: Which would you regard as the main priority for consideration in future Part L2A revisions.**

185 I03: I actually think that they need be careful that they not try to run before they can walk and I think they would help an awful lot if they actually do some post contract analysis not just design. And a lot of people often don't review the SBEM calc as the job's going on. And I find it difficult with our guys saying 'look if you're changing stuff on the job please let me know so that I can update the SBEM calculation before the 11<sup>th</sup> hour and before you start coming to me saying I've got a handover on Monday, I need the compliant SBEM calc'. They're probably going to try and reduce the air permeability, I would suspect in new Part Ls and I think they need to get people detailing decent junctions on that beforehand. And help with some kind of toolkit for architects to make them realise how buildings do leak, because I don't think they understand. That's another Part L thing.

**IN: You mentioned something earlier about the responsibility.**

195 I03: I think they need to make the responsibility clear as who's responsible for Part L compliance. And ultimately I think that comes down to the main contractor. It helps in my position, because I can actually phone architects up because nine times out of ten they're (novated) or working for us and I can call up and say 'I want the U-Values, I want this or I want that'. Whereas if an architect phones one of my building services contractors and says 'can I have the seasonal efficiency for the boiler you're putting in' he's going to think 'that you're an architect, you don't need to know that'. And that's where it helps, but I think they do need to clarify the position on who is responsible for each item.

200 The other thing that causes no end of grief is the final print out that you send to building control, now that you can't doctor it because it comes out in a PDF version. There are certain items that they say – see separate submission- which nine times out of ten sends our site guys into a complete panic, and they phone me up and say, 'well where's the separate submission?'. And it'll be things for like the building log book, which will be there but, I think they should just take that off of the form or out it as a tick 'has the building log book been issued?' or something like that. So that you can either tick it, so that you can either amend it or put comments in those boxes. Because, as I say, I probably get a phone call every time I issue it, because there are these blind statements. I forget some of the others but 'developer responsible for this item', 'solar overheating' or what have you, if you've got a naturally vented building, you'll get, you'll need to check that summer overheating is done, but SBEM doesn't do that, so all it says is-see separate submission. And as I say, it's not defined, it's not there, they don't say what it is and to the poor man who issued it, they go mad.

210 The other thing that would be nice, but it a nicety would be to be able to add your logo to the PDFs that come out in one way, shape or form something like that. So you would actually be able to attribute, this is a Fitzpatrick project, this is your SBEM EPC, and it's been created by us. So you look as though you're taking responsibility for what you're issuing, rather than a bland statement.

**ANNEX: (Added later as per request of the interviewee)**

I03: The other big bug there is that there is no telephone helpline with SBEM, and that really winds me up.

**IN: That is on purpose.**

220 I03: Yes, I'm sure. The problem I have is that if you're so engrossed in a calculation and are under pressure to create that calculation, you really need the answer. And by emailing back and forth, I'm not convinced that you're getting the right answer because they don't understand the question. And that really does bug me. I think there should be a helpline for competent persons, so you give them your competent persons number or whatever, so they know you know how to use calculation, you've got a specific query that you won't have  
225 been able to solve and that you're competent. I can understand not having a helpline for the general public, but I think they really need to think about that because that really does wind me up and does hamper you doing things.

**IN: How would you recommend that these issues be dealt with?**

I03: I think they need to be dealt with through the guidance to the legislation. I think they need to tidy  
230 everything up, and also I think they need to as I say walk before they can run. Because I think SBEM got an awful lot of bad press initially and I think it's a little unjustified but it was because it was new and because nobody really knew about it or understood it and I don't think that that was particularly fair, but it's still got that hangover, and they keep sending new versions and new versions and revised this and revised that out and the industry could do with a rest, so people get into the compliance bit and understanding how they do it.  
235 And I'm not convinced that most building control officers understand SBEM. All they want is a piece of paper. And sometimes it would help, I have been once on one particular job, to be challenged on the SBEM calc, and to go through the SBEM calc and explain why you've done things on it. That was done by a consultant that we worked with, and they went through a project and they were actually looking to improve the calculation rather than just adding bland defaults, and I think you can fall into that trap with SBEM, is instead of searching  
240 for the information you just hit the default button.

The other thing, while it comes to me, is that they could really help by sorting out the building services zones, whether you could actually make multipliers for a zone. Because it is absolutely laborious going through upwards of 200 zones, all changing T8 to T5 lights or something similar or adding photo PLR lighting or what have you. And you have to do that for every single zone. Whereas if they could give you a button that says  
245 which zones have got this, and you click that and it automatically does it, then it would help.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

I03: It getting better, although I worry that it's now going to get worse.

**IN: Well how do you see it being improved then?**

I03: I think they've done it again with EPCs. They've initiated EPCs without enough assessors. And again, I  
250 haven't become an EPC assessor, not because I don't want to, because I just haven't got the time to do the assessment and give them all the tiny bits of information they want. If I had a month off, I'd be able to do it. But what they don't tend to realise in this day and age, you don't really get the amount of time that you would love to sit down and do things. So actually, it would take, I reckon to do everything properly for my EPC application it would take probably two weeks, which I'm doing, but its two weeks of half an hour here, and  
255 hour there because you have a day job to do as well. And I think thing will go backwards because there won't be enough people doing EPCs. So I reckon it'll be a year before the EPCs, even though they're supposed to be being done now, actually come into, you start seeing them being done properly. People may do a few, but, I don't think the route to gain, to get EPCs is fully understood. The fact that you have to now, which maybe they should have done with SBEM initially, is get the quality of each calculation assessed and accredited by an  
260 independent body, which they're doing with EPCs. I hate to think how long that's, what's that is going to do and whether that is going to hold up practical completion on jobs because nine times out of ten, if you think about the entire procedure, the two bits that nearly always hold out to the very last is doing the actual building air test because you're not going to do that until the building is almost practically complete. When the building is almost practically complete you're inevitably commissioning, so you don't want to be shutting  
265 down the building to be doing an air test. So it's normally left to the last minute. You then do that, which then the actual result of which needs to go to the finalised as built EPC SBEM calc. If that has then got to get sent to an accrediting body which then takes however many days to accredit it, you could end up missing PC or getting PC on a proviso providing the certificate, which I don't think is what is really meant and I don't think that that's going to fall through.



## Interview 04 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion?**

I04: I've done, I've thought of 2, because they're very, very different and I thought it was useful to come from 2 different ways. The first one is a hotel, is a (hotel name) hotel at (area), (station name). That particular one, we're working for the contractor and we're doing it right at the end of the project. It's being completed on Monday it's been handed over on Monday, so within a couple of days and we got the instruction 2 weeks ago and we completed it last night. The other project is (project name 2) which is an office scheme in central London, where we've been involved in the project for probably about 8 months so far. We've just come out of planning, so we're into detail design stage, it hasn't been built on site yet.

**IN: What were the main design criteria that were considered for each of these projects?**

I04: The, both projects because they're in London have a renewables requirement under planning, so we really, in terms of the (project name 2) Scheme, that's the one we kind of had an impact on ourselves, the design criteria was the architects drew a building, we had to make it work. It was a big glass box, we've had to undertake a number of different runs and simulations to look at glazing specifications, mechanical systems specifications to make it comply with building regulations and then to incorporate renewables within the scheme.

**IN: Did you have certain sustainability targets?**

I04: Yes it was 10% reduction CO<sub>2</sub> from the use of renewables on both schemes.

**IN: Which software did you use for this exercise?**

I04: We used IES or (project name 2) and we've used SBEM, iSBEM for the hotel.

**IN: Why was these tools chosen?**

I04: IES, we use generally, because it give gives us, we believe it makes it simpler in terms of modelling. So we've been using that because it's a longer project. For the hotel we had to do, our appointment was also to produce and Energy Performance Certificate for the scheme, and at the moment only myself, I'm the only person in the company registered to do EPCs and the software in which I'm registered to do that is SBEM. So for us it was a case of just do the same exercise using one piece of software rather than doing two.

**IN: How would you rate your proficiency and experience in using this tool?**

I04: As a company we're very, very experienced in using IES. I haven't personally undertaken the IES calculations for (project name 2). We've got a guy who's just gone through all the Low Carbon Consultants training and the IES exams, so he's as qualified as you can get at the moment. In terms of iSBEM, I've done the training and qualifications for that and I'm a certified user of iSBEM. I think both of those software, you probably need to spend quite a few years to learn the nuances and the problems with the software and how to get round them.

**IN: I forgot to ask this earlier, but which versions did you use?**

I04: iSBEM would be 3.1.a and IES is 8.9, sorry 5.8.2, I think it is.

**IN: Would you have preferred to use another tool?**

I04: I, I mean I would've preferred to use IES for the hotel because it would have meant that I wouldn't have to do it myself. Someone else could have done it. It's not necessarily a task I enjoy doing or is very cost effective for us to do. For myself, here as the associate, to be doing the Part L calculations. I think in terms of the, the software that I've used in the past and that it out there, we prefer IES. That's the one that we target to use.

**IN: Is there a particular reason for that?**

I04: We do a lot of other work in terms of day lighting, internal CFD sometimes, so the IES package enables us to use the same model for a number of different functions. So we can just move it to a different module, click a button and get different results from different types of systems. That means that we can save time, we can add value to projects and we can do a lot more than just a Part L calculation. The other software, they are primarily for use as a Part L tool.

**IN: Could you briefly describe the process that was involved with achieving Part L2A Compliance for your projects?**

I04: For the, for (project name 2) there was a number of assessments undertaken. We did a, what we call a baseline calculation - how we get to Part L. So we looked at all the energy efficiency options, different glazing specifications, increasing insulation, increasing air tightness, upgrading the efficiency of heating/cooling plant, ventilation and lighting systems. And we look at those each in turn so we can see the relative impact of each of the measures, because each of those has a cost, and from our client's point of view they want to know how they get there, but at the least cost and the least impact on perhaps the aesthetics of the project.

**IN: So it was more of an indicative study?**

55 I04: Oh no, well that was an in-depth study saying 'ok, we've built the building, we know exactly what it looks like, what happens if we upgrade the cooling efficiency from a standard air cooled package chiller to a free cooling chiller, therefore we increased the efficiency of that system, what happens then?'

**IN: So it was more looking at different design options?**

I04: Yes, so that's in order for us to get to a point where we can say we passed Part L with the current design.

60 And then once we've passed Part L, we then look at the renewables options on top of that, then we're actually, we're looking at tri-generation systems, we're use gas fired CHP systems to drive, to produce heating cooling and electricity for the building and we're modelling that using IES.

On the hotel site, it was very much, we received a package of information from the contractor which was 'we have installed this piece of equipment, we've installed this system, this is how we've built it' and everyone hoped that we'd pass Part L. We did pass, but not by much.

65 **IN: How were the different roles and responsibilities for each of the group members structured?**

I04: Is this relating to directly to just to Part L or general?

**IN: I mean generally, if you have the mechanical side, the contractor, you. How was the interaction structured?**

70 I04: The simple one is the hotel. We were appointed by the contractor to undertake that specific calculation. So the only contact we had was with the contractor. We were employed by them. We were just given that information just to plug into the software and churn out an answer.

On the office scheme, on (project name 2), it's a bit more complicated. We are providing sustainability and energy guidance for the team and we are a sub-consultant to the M&E consultants. So as they're offering their advice on the mechanical and electrical systems, we then feed into that from the energy and sustainability side. So we've got a much kind of wider role on the (project name 2) Scheme.

75 **IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**

I04: For (project name 2), it was undertaken at Stage C and then it was re-done at Stage D for planning submission. And we will, we're now at Stage E now and we're reviewing that again to have our kind of final design stage calculations that are going to be submitted to building control within the next couple of weeks. For the hotel side, we were brought in at well I think it was Stage, was it K, construction so within days of the final PC of the project.

**IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**

85 I04: Yes, we were completely reliant on information we receive from architects.

**IN: For both projects?**

I04: For both projects. So for the (project name 2), it was very much them looking to us to advise on U-Values and specifications of facades. They, they provided us with the kind of aspirational elevations and floor plans and we then had to feedback into that what the requirements were for the specifications of the façade. We're then reliant on the services consultants to provide us information on plant. Exactly the same situation on the hotel, except that on the architectural side we were reliant on them to give us information on U-Values and system performance. There wasn't time, obviously, for us to undertake an initial review to work out what it needed to be. It was very much a case of we had to model what was, what had been built.

**IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**

95 I04: For (project name 2), yes. For the hotel, no.

**IN: At what stage would you have preferred to undertake it for the hotel?**

I04: There was already a design team in place who did the first part of the design, so up to Stage E there's a team who'd done the design. Now at that stage, for whatever reason, there hadn't been a design stage Part L calculation. So from my point of view, from my relationship with the contractor, I've made it clear to them that our fee doesn't change actually from wherever we get involved- a week from the end, wherever we get involved a week after they've been given the tender package, we've got to do the same task. So we need to be involved-if we're working for a contractor- as soon as they get the tender package. As soon as they get the contract for the scheme, we need to be there doing the design stage assessment to say 'yes you can build it that way'. Because the only reason that we were able to comply is that they were using a ground source heat pump system for the building. If they hadn't done that, then they wouldn't have complied because the M&E sub contractor had selected fairly, fairly poorly performing water heating, water generating system for the scheme. Which meant that because it was a hotel and the large bulk of the energy was generating water, they would have failed if it hadn't been for that system, the ground source heat system.

**IN: How much time was approximately spent on the simulation exercises in total?**

110 I04: For the hotel it was, it was about 20 hours. And that included chasing for information input into ISBEM, the lodgement of the EPC at the end of that as well and the report, a small report. So that was a fairly concise exercise. For the (project name 2) , we have spent weeks. We've probably spent, first time we did it, it would've been a week's exercise to model it, look at all the options, look at the renewables, feasibility as well. And then every single time we come back to it it's probably 2 days. So in total so far we've spent 2 weeks, 115 definitely, but then with the nature of the project is you get a call then questions raised and emails that you spend 5 minutes on that you don't really lodge. But that adds up over time.

**IN: How did this vary from the time you initially planned to spend?**

I04: The hotel was as, was exactly what I expected to spend in terms of time. We get good fees for it mainly because of the, its short notice work, needs to be done now and you have to drop everything else and do it. 120 And it did involve working till 10 o'clock at night, a couple of nights, just to fit it in with other work. So you pay, you get paid for the inconvenience. The (project name 2) work was more time and its going to be a lot more time than was allowed for. Mainly because there's a lot of going back and changing things. That's because the architect is constantly changing the, the façade design.

**IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?** 125

I04: The hotel did. The (project name 2) office scheme didn't.

**IN: With regard to the (project name 2) scheme, what kind of measures did you use to achieve compliance?**

I04: We looked lighting control systems. So we looked at using more energy efficient lighting systems but we're also specifying IR controlled sensors, occupancy sensors that turn the lights off when they're not 130 required and looking at day lighting sensors. So all of that package helped as a single measure to comply. We did look at other options like different glazing specifications, more efficient systems, but the lighting had probably more of an impact.

**IN: And these were design changes?**

I04: They were things that we possibly would've done, the engineers possibly would've done anyway, but weren't in their initial documentation. So it was, I think it was more of a case of they'd forgotten to put it in 135 and then when we went through and said actually by doing this you could comply, they said 'oh yes we were going to do that anyway', but hadn't told us.

**IN: Which Input parameters did you observe as having the most affect on your results?**

I04: It was actually lighting had the biggest effect that we could control.

**IN: Describe approximately the variability in results that was observed as a percentage.** 140

I04: We, I think we worked out that by improving all the lighting systems, we could save nearly 10% off our initial hit. We weren't failing by much when we did the first run and by including those lighting systems, we saved almost 10%. And that's in terms of CO<sub>2</sub>.

**IN: How did these results feedback back into informing the building design process? (or was it separate?)**

I04: Yes, so the engineers then used the information from our report in terms of lighting controls and how that would be specified to prepare their detailed design documents, which they're doing at the moment. We also made some recommendations on the glazing and fabric performance, which has now fed back into the architectural design. 145

The problem we're having at the moment is we've just been issued with a list of, I think its 16 different façade treatments that the architects are looking at which includes, I think its 12 different types of glass and that, we're actually, there's actually a meeting today that my director here is going to discuss how that's going to work. I mean obviously from a design point of view, it's very difficult when you have that many façade, different façade treatments. From a construction point of view, you can never guarantee they'll put it in the right place. And from a modelling point of view, we can't always physically do it. So it's actually trying to 155 work out how we go from what was a fairly simple analysis- where we have glazing its one specification, where we have solid it might be a couple of options with the same U-Value- how we go from that to 16 different types of façade build up.

**IN: Are you formally accredited to carry out Part L2A compliance calculations?**

I04: I am on SBEM, iSBEM.

**IN: So you're a competent person?** 160

I04: Yes. I'm a Low Carbon Consultant and also a competent user under ISBEM. My colleague here who does our IES work is a Low Carbon Consultant. He, which means that he's competent to carry out Part L calculations. He's recently sat the IES exam to be a competent user under IES, but he's not there yet.

**IN: What route did you follow to submit your work?**

165 I04: For, well for. The only one we've really submitted in terms of anyone outside the design team is the hotel project. So on that one I've issued all the documents to the contractor and building control officer on the scheme directly. And they have all the output data, output reports from iSBEM. On the office scheme, we've only issued things internally, and we will be- once we get through this issue of what we model-we will be issuing a full report to building control on that. And by the time we do that we will have the final accreditation details from my colleague.

170 **IN: Did you use any internal methods to assure quality control and the validity of your results?**

I04: No, that's, that is one thing that we are establishing at the moment is to, is to set up a system where we can monitor inputs. What we do have at the moment, what we have is we have a student who, a knowledge transfer partnership student, who's here for three years building a database for us for past projects. And so we actually put all of our output data into that database.

175 At the moment it just sits in the database and you can review it and you can see. Normally you can see when something is wrong, you know, significantly wrong because the values for meter squared are very different to other projects, and you can flag that up. And what we're also creating is an automated system that says when you put in the values, well there something wrong here. And our internal procedure will be to- as you do the calculation- to update the database as you go. So it's an instant thing rather than 2 months later when it's too late to do anything about it and you really want to know there is an error straight away. But you also rely on people experience. We've done enough Part L calculation to know when something is wrong. And if it's a small error then it kind of gets absorbed within the total results anyway.

180 **IN: Did your building, the hotel, pass with regard to the requirements of building control**

185 I04: Its, it was issued to building control yesterday last night, so we haven't had any feedback from them although I have never once had any feedback from building control on any report that I've done. So I'm not expecting any.

**IN: Did any of your team have any contact or interaction with Building Control?**

190 I04: Not on these because they're new build schemes and therefore the rules are black and white and everyone know kind of what they're doing and gets on and does it. We'd only actually have, make contact with building control with regard to Part L if we're doing a refurbishment project and therefore it's slightly woollier it terms of what the rules are. And we'd agree those rules and what we needed to do right from the outset.

**IN: What are the main issues, if any, did you encounter during the simulation process?**

195 I04: The main problem is the collection of data. Is making sure what we're modelling is representative of the building. Now, there's limitations within the software that means you can't fully do that. But in terms of the information that we get from people, it's never in the right format. For example, I got an air conditioning spec from the contractor on the hotel project, but it doesn't give me an SEER and an EER, the values I need to plug into the software. The industry doesn't work using the same values as the software requires you to input. So there's a bit of chasing to get that information or you have to make a bit of an assessment as to what you need to fudge it to become to be put in the software.

200 **IN: You mentioned limitations in the software, so did you experience any difficulties with the software in both cases?**

205 I04: Not so much, well yes. I mean on Part calcs we've got a tri-generation system, so we're using a gas fired CHP to produce heat, to drive an absorption chiller, to produce cooling. So slightly from an engineering point of view it doesn't quite make sense, but from planning point of view that's what they want in London, or wanted in London. You can't model that in IES. If you put in CHP in IES, it assumes that its heat system and therefore looks to take that heat off as in space heating and air heating. It can't then use it as through an absorption chiller to offset the cooling. So you have to make a judgement as to whether you're going to include it at all, so you have to if your client is spending hundreds of thousands of pounds and you can't say there is no impact, so you have to put it in. Then you either have to do a hand calculation to work out what the comparative efficiency of the cooling system would be or you just have to tick the CHP box and say I know it's not going to be the right answer, but that's all I can do.

**IN: And with SBEM, no problems?**

215 I04: We had exactly the same problems in that you can't, you can't model a CHP. On this particular system it was a ground source heat pump system, but it wasn't doing all of the load, so we had, we also had boilers and chillers doing the load. Now, you have to then do a calculation, a hand calculation, to work out how the relative efficiency if you've a bit of gas fired, a bit of electric driven heat pumps. The problem is the calculation which is in the SBEM handbook says you work it out as the proportion of the annual heating and cooling load. But you don't know what the proportion is, because the software can't tell you that. Because the problem is

220 you have a piece of kit that running all year round, so that's the heat pump. That might be doing 50% of the peak installed load, but might be doing 95% of the annual load. But the only way you can know that is by doing an annual simulation using something like IES to tell you when, what hours the backup plant has to run for. So SBEM is asking you to put an input in that you can't possibly know, so you have to guess.

**IN: Or use another tool?**

225 I04: Or use another tool. But even when you use IES, it asks you the same question. But you know that you can run a simulation but then you have to apply different templates and other things to make sure that that's correct. So it's a very, very long winded way in order to adjust your efficiency. And if you have to do that for both cooling and heating and hot water-as is the case on my one because we used ground source heat pumps in the hotel to do some pre-heating on the hot water-you have try and make some kind of guesses and  
230 assumptions to claim some benefit from the systems you've put in, but without over estimating the savings. Now those 3 figures-heating efficiency, cooling efficiency and hot water generation are critical in establishing the output. So you can spend, you spend 2 days putting in all the detailed information; geometry, measuring every single window and door, and every single part of internal wall, internal floor, external façade. You spend a lot of time doing that and in 5 minutes you have to guess what the efficiency is, which is actually the  
235 core of the whole output.

**IN: Which would you regard as the main priority for consideration in future Part L2A revisions.**

I04: I think, well its very complicated because I can understand it from the governments point of view that f you make something too complicated, it only needs to get more complicated. Because once you start going into detail on IES and you start trying to really replicate, then you start burrowing down to different levels of  
240 difficulty and detail that you don't really want to get involved in. It does want to be an overview without too much detail.

The problem they have is that they haven't really allowed for all these new technologies that the government itself is promoting. If you have a standard gas fired system or a standard electric system it works fine. It's actually when you start to try to incorporate the renewable technologies and the systems that mean that you do have a small piece of kit, ground source heat pump, biomass working all the time and you top it up with other technologies that those detailed scenarios are ignored by the government, even though they're the ones  
245 promoting that and pushing that heavily. So it's slightly bizarre that they've ignored that. So I think it's actually calculating the energy savings from these low and zero carbon technologies which is important, because if there isn't seen to be the benefit from doing it in terms of the Part L calculation, then developers won't spend money.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

I04: Yes, I think it's good as a starting point. I think what we've got at the moment is very good as a starting point. Obviously it was a big step to take in 2006 to bring out this software. It's very different from what was there before. It's moving in the right direction. So from a positive point of view, you've got to start somewhere  
255 and you've got to create something to know what not to do next time and to know what the mistakes and issues are. So that's, I think that what they've done. Unfortunately, I don't think they're really looking, looking at how to improve it. The feedback is that they've created it, and that its. You've got to make do. You got to, you know if you've got to fudge things, you've got to fudge things. We're not going to change it, it's there, use it. Whereas in actual fact I think that the real way of moving forward would've been to take on  
260 board these comments, take on board these comments and actually update the tool every 2 years or every year. And though they've made minor tweaks to the SBEM tool, which -what we're on version 3.1.a-and they've they're then making minor tweaks to the IES to keep up with that, I think it needs to be more wholesale changes. I think they really need to change the good software and the program side, because it's actually it's more of a case of how it calculates everything and it fundamentals and how it calculates things that we need to  
265 change. I don't think it's just, you know, polishing the surface and changing the small bits here and there, I think the overall part of the model how it calculates things needs to be changed.

The NCM profiles as well that everyone has to use to generate the occupancy data, the usage data, temperature set points and all of that information I think also needs to be looked and updated. There's a number of thing in there, particularly the hotel, there's an error in the profile for the hotels which means that  
270 hot water consumption is wildly over estimated in hotels. Now everyone knows that, and everyone says 'yes, that's the problem' and all you need to do with hotels to comply, is to put in a very efficient water heater and it's very easy. So we, everyone knows there's a problem, there's a loophole there, but no one's actually changing that. And the government aren't revisiting those NCM parameters. Now we've got a number of clients also who-on that particular topic of NCM- who say 'well I want run my building at a higher

275 temperature', you know, 'I'm happy with 24 degrees in the summer, it doesn't need to be 22'. Well the Part L calculation already presets that temperature, so there's no, from the developers point of view, there's no benefit for Part L or the EPC or any other formal document from doing that.

So there's a lot of, a lot of different energy efficiency measures, I think, like temperature set points, like putting in small bits of kit that are cheaper to do, that run all year round, that contribute quite significantly, that the  
280 Part L calculation just ignores and it deals with kind of big items, but ignores some of the ones that can really make a difference.

**IN: And with regard to the methodology, the ways the legislation's set out, do you have any comments regarding that?**

I04: I think, not to be too rude about it, I think the building control officers and approved inspectors need a  
285 kick up the backside because they need to get out there. They need to be asking for this documentation. Because at the moment, if we weren't- as consultants-if we weren't, if we didn't have our professional name to protect, we could just not bother. And I don't think that the large proportion of building control officers out there, who wouldn't even notice if we didn't do the Part L calculations. They'd still put a tick in the box, they'd still give a completion certificate at the end of the project. No one's actually asking for this information,  
290 and because no one's actually asking for it, no one's actually got there head around how it actually all works.

I mean the fact that there's now 2 stages of calculation- design stage and as-built- I can guarantee that , well every single time I've said that and I've worked on probably 30-40 projects in the last year and probably 80 projects I've been involved in since the new regulation have come out. Every single project team that I've spoken to has not understood that, has not understood that actually you do one before you start work on the  
295 sight and you do one right before the end to see I've done what I've said that I'd do. And it's been us who've had to push it and say 'when do you want you're as built certificate? When do you want your calculation done? Can I have the information?' And if it wasn't for us pushing it, it wouldn't happen. And I'm pretty sure in a lot of the cases no one would really notice.

I think with the EPCs because that's the important part of the Part L process now, that it'll be forced along  
300 because you're having to do the EPC and the building control officer will need to be a bit more savvy about asking for the EPC. Because they ask for the EPC, they may ask for the as-built, but I think probably realistically, it will still get missed because they'll just ask for the EPC certificate and the as-built calc will get ignored.

## Interview 05 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion?**

I05: The example I've selected is a (name) college, which is a new further education college in London near (area name). So it's quite a substantial block, about 6 or 7 storeys with basement, workshops, classrooms, open learning centres. So it's quite a large and sophisticated building, which they're aspiring to achieve fairly good energy targets on. It's quite interesting in terms of its architecture with some overhanging floors and lots of external shading devices and so on.

**IN: Can I ask what the systems were that you used for the project?**

I05: The mechanical systems for the building?

**IN: Yes.**

I05: There's quite a mix actually because of the range of different spaces and the needs. There are a number of different systems within the building, ranging from some areas which are naturally ventilated through a displacement, sorry through a stack effect, through an atrium to other areas which are using mixing systems. Other areas, some areas I think have got displacement systems in.

**IN: Quite extensive systems.**

I05: Yes it is. There's a real variety. Probably too many.

**IN: What were the main design criteria that were considered in this project?**

I05: Probably the, one of the key criteria were the energy targets that were set by the planners in relation to the project. And I don't think that they were considered in the early phase, but it really related to the overall efficiency of the building but also the renewables targets. So we were looking to get the energy consumption down so that we could then put the renewables on top. Although just looking at the initial report, that wasn't considered at that stage, it would appear. I believe it was about 20% better than Part L was the overall target for the building when all measures were considered.

**IN: That was the sustainability target, the 20% improvement?**

I05: Yes.

**IN: Which software did you use for this exercise?**

I05: We used IES.

**IN: Which version?**

I05: It well, that's a good question. It was probably started in 5.6, I think and finished off in 5.8. Which is a potential issue.

**IN: Why was this tool chosen?**

I05: Really, as a group within (this company) we were involved in dynamic modelling prior to the new Part L regulations coming in. So we saw it as an opportunity for us, you know, to actually get into the field of doing the regulations assessments really based on our experience and having the tools available. So we, we've never really adopted any other tools. We have assessed things like SBEM, you know, we've never. We used to have Tas in the company but moved to IES some years back and we you know haven't seriously looked at going back. So really IES is the default for us because that's what we do as a group in terms of design support primarily and the building regs assessment is a secondary thing for us.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training....etc)**

I05: Quite high, I would say.

**IN: So you've been using it for a number of years.**

I05: Yes

**IN: How many?**

I05: About 4 years now.

**IN: And have you had any formal training?**

I05: I learnt it during my Masters course at university, well not sure that qualifies as formal training. I haven't had any formal training from IES directly, but do internal courses and at university we used it.

**IN: Would you have preferred to use another tool?**

I05: No, No.

**IN: Could you briefly describe the process that was involved with achieving Part L2A compliance for your project?**

I05: Yes. The process we go through is to pick up the initial drawings from the architect to model the building. And initially, we'll then carry out some compliance runs pretty much based on the default settings that IES puts in, you know, which may not be realistic, but they give us a starting point for the assessment. We'll then run through a series of sensitivity studies. Where we actually changes fabrics, for example, glazing areas,

55 system efficiencies, system types and so on. And so we'll kind of go through this sort of cascade of different options and see what the improvements are and sort of layer one over the other to then, you know, to give us a route to compliance. And you know, that may not be a definitive route, but you know it's one of the options.

**IN: So it's an ongoing process?**

I05: It is an ongoing process and I mean that goes through discussion with the design team, you know, as to the options that we're changing, whether they're feasible, whether they're desirable for other reasons.

**IN: How were the different roles and responsibilities for each of the group members structured?**

I05: Roles and responsibilities? Well the, I mean, the, probably the key group is actually the services group here. I mean they're responsible for the design ultimately, in conjunction with or in working with the architect and the client. And so we, in this case we're actually appointed to the client alongside the services group, but nevertheless we need to work closely with them. It more often probably that we're actually sort of appointed internally effectively by the services group. And so we feed back to them more directly, or sometimes through them. But it's generally beneficial to be appointed directly to the client and to have a more direct consultation with the architect and other members of the design team.

**IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**

I05: We did our initial compliance at Stage D, although we were starting to model the building towards the end of Stage C, but yes it was at Stage D so it was schematic design where we did our first assessment.

**IN: Did you require any form, if any, of co-operation or help from other specialists?**

I05: Not for actually doing the simulation. But, I mean obviously we need to talk to other people in relation to the design solutions that we might be considering. And I mean in this case, there was a big debate over the atrium and the roof light that was going to go in and act as the vent to the atrium stack and the noise issues surrounding that. Lighting and solar control issues surrounding that. So yes, we needed input from specialists there for example. Many other areas as well; the ground source heat pumps that were going into the building and the renewables, again we need specialist input. So yes.

**IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**

I05: Yes

**IN: How much time was approximately spent on the simulation exercise in total?**

I05: That's a good question. No, not very easily. But it was probably, I would say about a month's worth of work all in for one person. That's very approximate.

**IN: How did this vary from the time you initially planned to spend?**

I05: It was longer. It did take longer on this one. We underestimated really the complexity of the building I think when we first assessed this one.

**IN: So it was significantly longer than you planned**

I05: Yes.

**I06: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**

I05: No not from the very first compliance run, but as I say we tend to just use fairly you know sort of stupid defaults. But within the first round the sort of iterations we were able to demonstrate compliance.

**IN: If not, what kind of measures did you use to achieve compliance in later runs?**

I05: Well they included, I'll tell you for example; this is the graph that actually shows the sort of progression of the iterations. And this is our notional building, and this is all our default values. So one of the first things on this one was new systems. So that included specific fan power for systems, seasonal efficiencies for the condensing boilers, fan coil systems for the IT spaces, seasonal efficiency of chillers, heat recovery in various areas. So it was all sort of system improvements at that level. Then lighting efficiencies, then glazing was G-Values down to 0.4 and U-Values to 1.6. And I think that was pretty much where we got compliance, but then U-Values for walls and roofs and then power factor correction was added in, and that was only a fairly marginal pass at that point, by 2% or so, but kind of demonstrated that it was feasible to achieve.

**IN: So these were mostly design changes not alterations to input parameters?**

I05: Yes they were design changes actually, yes.

**IN: Which Input parameters did you observe as having the most affect on your results?**

I05: I need to peek to the graph for that one. Systems I would say in this one. Usually for office buildings for example we usually find that it's the lighting. Either lighting or systems. But in this case because it was a slightly more unusual building it was the systems that had the biggest effect.

**IN: Describe approximately the variability in results that was observed.**

I05: From where we started till where we got to? Well, in percentage terms, well I mean we were about 5%



- 110 lower than the base, so we were about 25% reduction, yes roughly.
- IN: How did these results feedback back into informing the building design process? (or was it separate?)**
- I05: Well we, I mean at this stage many of the changes that we implemented were done really just to see what had the biggest effect so it was a case of going back to design team and discussing the feasibility of each of these changes and what that actually meant in real terms to the design and to the cost and so we worked with
- 115 them to actually implement.
- IN: So these were actually incorporated in the design.**
- I05: Yes.
- IN: Are you formally accredited to carry out Part L2A compliance calculations?**
- I05: I'm not. One of the guys in my group is. He probably did most of the detailed work in the end and
- 120 certainly produced the final report.
- IN: What route did you follow to submit your work?**
- I05: At that stage, well it was the first stage report that was submitted to, just to the design team that's, that was an internal document essentially. And then the analysis was repeated with much more detail at Stage E, which was a much longer process and better documented. And that was submitted to building control as well
- 125 as the design team.
- IN: The accredited individual in your company was the person names as the person who did the compliance calculations?**
- I05: Yes. Should've been anyway.
- IN: Did you use any internal methods to assure quality control and the validity of your results?**
- 130 I05: Other than sort of having people check over the model quickly and check over the reports as they're issued, we don't really have a really thorough formal process internally for actually checking them, no.
- IN: Did your building pass with regard to the requirements of building control?**
- I05: I certainly haven't heard otherwise. I haven't actually heard one way or the other. We kind of submitted the report and that was largely the end of our involvement in the project.
- 135 **IN: So you're assuming that you did?**
- I05: I'm assuming that we did. I'm assuming someone would have told us if otherwise.
- IN: Did any of your team have any contact or interaction with Building Control?**
- I05: No, not prior to the submission one this one. No.
- IN: What are the main issues, if any, did you encounter during the simulation process?**
- 140 I05: I think the, the main issues really revolve around the design and whether changes we wanted to make or changes that we were proposing would be helpful to Part L, were palatable to the architects in particular and the client. For example, I mentioned the roof light earlier and the solar shading. And, you know, the client wanted and absolutely clear roof light with no solar control at all. Which wasn't at all helpful. Firstly from just you know a practical point of view of the building but secondly from the cooling loads that were going on the
- 145 upper spaces and the contribution that then meant to the building emissions. So, you know, we were very clear that there was a degree of solar control required for the building, which the client didn't want. The architect was stuck in the middle trying to resolve it. So it was design issues are the main thing.
- IN: So no issues with the software of the actual methodology?**
- I05: Not really, you I mean it's, I think there are issues with the software and the methodology. I think it's easy
- 150 for people unless they're very careful with the software to specify things incorrectly, you know not to tick all the boxes that need to be ticked, or to cover all the details that need to be covered. And I don't think there's, there isn't much of a safety net there in terms of people doing things wrong. And you know I have to say your question about QA procedures, we don't help ourselves a great deal in that so I think there is some risk of variability in the results as a result of that. But you know, we you know we're relying a lot on our experience
- 155 with the software that we're using day in day out to quite a high level. You know, we learnt how to use it so we don't see these as issues anymore just features of the software, you know, and we just breeze through them. It's the design issues that we get stuck on rather than the software issues.
- IN: You mentioned that you had a number of systems within the building. Were you able to model them correctly or realistically using you software?**
- 160 I05: Yes, we believe so yes. We did have to go to some degree of complexity. I don't know how familiar you are with IES. The HVAC module, for example, was implemented for a number of areas within the building in order to account for the systems correctly and that's perhaps something we wouldn't normally again for a conventional office building. So yes, there was a degree of complexity in the building and we had to consider how to cover that within the model.

165 **IN: And the incorporation of renewables, were you able to correctly model them as well?**

I05: No the renewables were added on as a post processing exercise to the model. I don't think we saw a way to incorporate those into the model effectively.

**IN: Which of these issues would you regard as the main priority for consideration in future Part L2A revisions?**

170 I05: I think it needs some clearer guidance on the modelling methodologies and how you should model different systems. I mean the other thing is some of the templates that are used, the occupancy templates again for offices, for example we really find that the internal loads are very high and the heating loads as a consequence are very low. And when we come to look at the contribution of renewables, how you'd size them in reality compared to how you'd size them to pass Part L can be a very different, a very different story.

175 **IN: Are these the NCM templates?**

I05: Yes. So I think that's a big issue. And you know, I think there's, there's different ways of modelling you know a number of different things and some people, one person will do a model differently to how another person will do it. And they both seem to be perfectly acceptable within the kind of grey areas around the methodology. I think it needs a slightly tighter process.

180 **IN: How would you recommend that these issues be dealt with?**

I05: Well, yes. A very difficult thing. I think, I think, you know, it needs someone to actually go through it In a bit more detail and to layout a clearer set of guidelines as to how models should be undertaken and, you know, whether you can account for the effect of trees which are shading the building and this kind of thing which we typically don't, but I'm aware that other people do it. You know. Is that allowed? Is that valid? Is that not? And you know, I think the software houses themselves could also you know be clearer. Either make their interfaces clearer or give clearer guidelines on the correct way to represent different types of systems and, you know, what should be accounted for. I think it's an education issue more than anything.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

190 I05: I think the overall procedure is quite useful. It helps to focus people on the design aspects and what they're doing and how it influences the building in different ways. And you know, whilst giving them a fair amount of design flexibility compared to the previous iteration of the regulations, I think it's a good thing from that point of view. You know it just gets people thinking about the building and building performance. I think one thing, you know, that would probably in my mind be useful would be to actually have some more specific targets in terms of emissions per meter squared for different building types rather than comparing to a baseline notional building of the same shape, I think you know perhaps some reference.

195 **IN: Some benchmarks?**

I05: Benchmarks yes, would be a more sensible approach. But I think overall there's a lot of value to the procedure, you know, outside of just the assessment itself, But there's, there's an awful lot of grey areas around it which could do with clarifying.

## Interview 06 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion?**

I06: It's a school. Secondary school, about 10,000 square meters. It's prominently naturally ventilated. Yep. Anything else you need to know?

**IN: If you have information about its basic components, the other systems you used and where its roughly located.**

I06: Right. Located in Yorkshire. It is, the actual site is a complex site. There's some existing buildings which are being refurbished and there's some new build. So if I concentrate on the new build, it is, as I said it's naturally ventilated, the main heating is gas-fired boilers, but there are a number of renewable energy systems that have been looked at to actually achieve a BREEAM target, rather than a Part L. So we're actually getting better than Part L compliance.

**IN: What were the main design criteria that were considered in this project?**

I06: It was BREEAM excellent. That was really the only, the main driver for this. I mean there's, we needed to provide comfort, you know, BBI101 comfort for the classrooms without resulting to cooling.

**IN: Those were the sustainability targets?**

I06: Yes

**IN: Which software did you use for this exercise?**

I06: IES.

**IN: Which version?**

I06: It would've been 5.8.2, it might've been 5.8.0, I think. 5.8, something or another. Yes.

**IN: Why was this tool chosen? (Were there any influencing factors-financial...etc?)**

I06: It's the one that. It's the one, we use IES as a practice. So we'll generally analyse all the buildings for Part L using that tool. I have used SBEM before, but it's not really, it's not really applicable because there's all the other elements that we can address; heating and cooling loads, comfort assessment, energy consumption predictions which we can only do with IES. Whereas with SBEM, it's just the one tool, the one element.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training....etc)**

I06: Very experienced, very proficient.

**IN: And how many years have you been using it for?**

I06: IES, at least about 6 years. Before that we used, I used Tas. I probably used that for 10 years before that.

**IN: Would you have preferred to use another tool?**

I06: No. No.

**IN: Could you briefly describe the process that was involved with achieving Part L2A compliance for your project?**

I06: Yes. The, after building the actual model, what we do is look at the, the carbon emissions for each element for the heating, cooling, fans, pumps and controls, lighting, etc not to see which ones are the largest, to identify which ones we can get the most savings from. We'd normally apply sort of the base, yes, the basic fabric U-Values and plant efficiencies based on discussions with the architect and the building services engineer as to what they're proposing at the time and use that as a starting point. For schools, I know that the lighting energy-well particularly with IES-the lighting energy consumption is a, is one element which I always look at for savings. And heating can be quite a large element, particularly as it's naturally ventilated, there's a limited amount that can be done about, with that with (Part L) insulation standards and the solar, solar gain of course. On the other hand, it's always reasonably high as the fans, pumps and controls. So lighting, fans, pumps and controls are the first things I normally look at in most projects and if it's predominantly naturally ventilated, it's the building fabric insulation and heating system efficiencies.

**IN: How were the different roles and responsibilities for each of the group members structured?**

I06: Right. I was supervising a, one of our engineers who's had a couple of years experience with IES to complete the work.

**IN: So he did the modelling then?**

I06: He did the modelling and what I tend to do is get them started and get them looking at the various emissions and suggest ways of improving, rather than spoon feed them.

**IN: So did you work with other people, maybe mechanical, MEPs?**

I06: Yes, I got the, the person who was doing the simulation to talk with the architect and also the building services engineer to obtain all the relevant data and I got them to make suggestions, what improvements could be made.

**IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**

- 55 I06: This was at Stage D.  
**IN: Did you require any form, if any, of co-operation or help from other specialists?**  
 I06: No. No.  
**IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**  
 I06: Oh yes, yes.
- 60 **IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**  
 I06: It would've probably been, in total probably about 2 weeks. So that about 80 hours. The geometry was fairly complex with the building. So we actually had to, it was a curved building with a sloping roof, which is probably the most difficult to model. The actual, there were a couple of existing buildings which were rectilinear, they didn't take long at all, they probably took about a (day).
- 65 **IN: And you incorporated them within your model?**  
 I06: Yes, well we had 3 separate models. So there was 3 separate buildings and then we merged the results together to get an overall BREEAM.  
**IN: For the entire site?**  
 I06: For the entire site, yes, to get a BREEAM target, because it was only the new building that had to pass emissions calculations, whereas the other ones just had to meet minimum standards. But we did the carbon emissions calculations because we needed to for BREEAM.
- 70 **IN: How did this vary from the time you initially planned to spend?**  
 I06: It was probably a little bit more than usual, and mainly because of the engineer doing the work would probably normally take longer than if I would usually take if I did it myself.
- 75 **IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**  
 I06: Yes. yes  
**IN: Which Input parameters did you observe as having the most affect on your results?**  
 I06: Lighting and lighting control, yes.
- 80 **IN: Is this in general, or just for this project type?**  
 I06: Its is in general and I think it is due to the way the software does the calculation at the moment.  
**IN: Describe (approximately) the variability in results that was observed (in percentage).**  
 I06: It could be as much as 10%.  
**IN: 10% reduction in CO2 emissions?**
- 85 I06: Yes, or may be more sometimes. Depends on what assumptions we put in.  
**IN: With regard to?**  
 I06: Lighting control, yes.  
**IN: How did these results feedback back into informing the building design process?**  
 I06: Well, what we do is we do a report stating all the system efficiencies and building fabric insulation that we've assumed in the analysis and what those minimum standards need to be to achieve the actual result we're looking for. So that sort of forms a basis for the further design for the mechanical and architectural design.
- 90 **IN: So changes were made to the design after your results?**  
 I06: Yes, yes.
- 95 **IN: And these were architectural and systems?**  
 I06: Yes. So I mean generally what we find is that the architect likes to go for the minimum building fabric U-Values as a standard and my view is that we should always push that and improve the building fabric first, even though it perhaps doesn't have a big as effect on the results as I thought it would have done based on my experience with buildings, modelling buildings.
- 100 **IN: And why do you prefer doing that?**  
 I06: Prefer improving the building fabric? Because when the building is built, that probably really the only opportunity to improve the, to get the fabric performing as well as, to put in the insulation. Because it's very, very hard to retrofit. Whereas a building services system is..  
**IN: You can upgrade?**
- 105 I06: You can upgrade that after 5-10 years. Whereas the building fabric, it's probably there for life.  
**IN: Are you formally accredited to carry out Part L2A compliance calculations?**  
 I06: I'm competent to carry them out. I'm in the process of getting registered for the EPC certification. So I've passed all the exams for the software anyway.  
**IN: And that's using which software?**

- 110 I06: IES. I've also been on the SBEM course, but I didn't take the exam because I didn't think it was worth, worth the money.  
**IN: What route did you follow to submit your work?**  
 I06: Competence.  
**IN: Did it go to building control?**
- 115 I06: Yes, yes.  
**IN: (I understand) for building control, they have to have someone that's registered to sign off.**  
 I06: They don't.  
**IN: They don't, really?**  
 I06: No. The person doing the calculation has to be competent, they don't have to be accredited. Building control can accept an accredited person's calculations without, you know, as they are. And what I find generally happens is that for people with experience, it's normally, sometimes the building control officer will ask a few questions about the Part L and actually realise that we're experienced and competent in doing them.  
**IN: So based on your personal experience?**
- 120 I06: Yes. And it seems ridiculous that somebody with a lot of experience has to sit the exams and you know, it's a lot of wasted money really. Basically, I train up the people in (this company), or I initiated the training within (this company) for the experience with Part L.  
**IN: So it's ridiculous for you to actually sit for the exam?**  
 I06: Yes. I actually have done the IES one for the energy performance certification.  
**IN: Did you use any internal methods to assure quality control and the validity of your results? Please describe these methods**
- 130 I06: Yes, we've checked the model against what we'd normally expect from that, you know, that sort of building type.  
**IN: Against known benchmarks?**  
 I06: Yes, and the actual, the building services standards that we were assuming, you know, everything was in line, so we're improving solar control, heating energy consumption goes up, overheating comes down. So all those sort of checks were made.  
**IN: Did your building pass with regard to the requirements of building control?**  
 I06: Yes.  
**IN: Did any of your team have any contact or interaction with Building Control?**
- 140 I06: Only in the submission of the report. And this is, they haven't got to the construction stage yet, but the design submission has been done.  
**IN: What are the main issues, if any, did you encounter during the simulation process? Please describe these issues.**  
 I06: I suppose the, because this building had a number of renewable strategies, they're not necessarily that well represented in the Part L calculations. Some of the rooms we had earth ducts because they were internal rooms, and the benefits of that system weren't taken into account in the calculation procedure. I could've done, we could've done it if we had spent a lot more time doing that. But it wasn't actually worth our while adding those, you know, the time taken to do that wouldn't have been worthwhile.  
**IN: Some strategies weren't represent able within the tool?**
- 150 I06: Yes.  
**IN: Did you have any issues with the methodology?**  
 I06: The actual calculation? The calculation methodology, for a start I don't think it's been published yet. Its, I think some parts of the methodology have been published, but at the moment, it's actually very difficult to get hold of the full methodology'. So it's actually quite difficult to understand what is actually going on in the software. When we get a predicted result that might not necessarily be, seem that sensible, you know, it very difficult to trace what's actually happening.  
**IN: So you have to trust your own judgement?**  
 I06: Yes. I mean for one instance, if you've got a building that is cooled, what I generally find is that if I improve the building fabric insulation, the actual emissions go up not down, particularly for offices.
- 160 **IN: Why?**  
 I06: Because the, what's happening is the heat loss through the fabric is less, so that pushes up the cooling load. However, I know in reality, that's not necessarily the case. Certainly from my energy modelling experience, that is certainly not the case. And I do know there are a number of simplifications that have been made in the methodology that are not representative of buildings and give that result. So, what that does is for

165 any building that is cooled, or any office building that is cooled, it's pointless actually improving building fabric U-Values. Which I think is a mistake, because all the building pre-heat is done outside of occupancy and that will be greater than what's predicted by the software. So it's not going to accurately represent the actual case. So it's putting more onus on the actual building plant and less on the building fabric, which I think is not really a good idea.

170 **IN: Which would you regard as the main priority for consideration in future Part L2A revisions and how would you recommend that these issues be dealt with?**

I06: Well there's, the main problem I see is generally the software underestimates heating energy consumption. One reason is the way internal loads are applied. Say for offices, the occupancy starts at I think its 7 AM at 25%, 8 AM its 50, I think its 9 AM it's at 100%. Its wraps down again in the evening at 6 or 7 at night. Whereas lighting and equipment come on at 100% at 7 AM and go off at 7 PM.

**IN: Those are the NCM templates?**

I06: That's the NCM templates, so that's totally overestimating the lighting and small power load in those rooms in that type of building. So that's why heating energy consumption is always low. The other reason why heating energy consumption is always low is because the methodology states that all mechanical or natural ventilation should be introduced into the space at the outside air temperature. Now that's perfectly ok for a naturally ventilated building because that's what happens, but in a mechanically ventilated building its actually taken through an air handling unit, heated to may be 16°C or higher and introduced into the space. And the load, the heating energy consumption is likely to be about 20% higher if that is, if that is done for a mechanically ventilated building.

185 **IN: So any other issues?**

I06: There is a bit of a difference between SBEM and IES in that the methodology for the fresh air, the introduction of fresh air, is as I've stated. But I think SBEM, or a previous version of SBEM, I'm not sure if the most up to date version does this as well, is actually heats the incoming air up to a set temperature. Whereas the methodology states that that shouldn't happen. Now I think that for mechanically ventilated buildings the air should be heated up to perhaps the room temperature and then we give them the option to adjust that temperature so that we can increase the efficiency of the building.

**IN: Can I ask if you found this to be the case within the different approaches within IES as well, because there's SBEM approach and the dynamic?**

I06: So the SBEM approach in IES, follows SBEM, so yes.

195 **IN: So with the same program, the same building you get different results?**

I06: Yes, completely different results. The other area is lighting energy consumption. SBEM alters the lighting energy consumption depending on the percentage window area in the room, whereas IES doesn't. So for IES, the lighting energy consumption will be much greater than SBEM by a considerable margin. So again that affects results. Now I understand that IES are addressing these differences, but...

200 **IN: So any other issues?**

I06: That's probably the main ones, yes. I think the, in the old version of Part L 2002, I did a few buildings using the carbon emissions calculation methodology, which allowed the user to choose the occupancy, equipment and lighting profiles to suit the actual building. I did find I was getting much more reasonable results using that methodology.

205 **IN: Than compared with the elemental method?**

I06: No, compared with the current Part L, i.e. I wasn't putting in excessive internal loads to assume the heating and cooling, as is the case at the moment. The only problem with the carbon emissions calculation methodology is that it was up to the user to choose suitable internal conditions, so it was more open to abuse.

**IN: So if you have problems with the templates, then giving a bit of flexibility would sort out that issue?**

210 I06: Yes. I think the only other issues are that there are some building types which don't have the right room activities assigned to them

**IN: Can you give me an example?**

I06: Right. I think it's a nursing home doesn't have a kitchen, so in the past I've used a hotel kitchen to replace that. What else, yes it doesn't have a pool either although I suppose most care homes don't have pools, the one we've been dealing with does, so again we use a hotel as being probably the closest equivalent. So there's little things like that.

**IN: You mentioned you had some trouble modelling renewable strategies, have you had similar issues with systems, regular systems?**

I06: Yes systems, I haven't talked at all about that have I? Yes in general at the moment the approach between

220 SBEM and IES is a little bit different. In SBEM we can define individual supply and extract from a room, whereas in IES we can't do that at the moment. I believe that's changing, they're actually changing that. So we're rather limited to, as to treat a building that has some mechanical ventilation. Say like toilets, with a naturally ventilated building with radiators and they have, there is a toilet extract fan. In IES there was no way of inputting that extract fan, whereas in SBEM there is. So we've created a number of work-arounds to  
225 actually represent the system.

**IN: That's within (your company)?**

I06: Yes. I think generally other consultancies have been doing similar things. So there's all of these differences that add up to significant variation in potential output for a project. So if one consultant did a building, and another one did it, you know the actual results would be completely different.

230 **IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

I06: I think the systems need to be a lot more flexible. I think the methodology needs sorting out. And there needs to be applied some realism to that methodology, because I think the, particularly the approach of dumping the external air into a space untreated is completely wrong. I think that the, on systems, the fans pumps and controls, the auxiliary energy consumption is, leaves a little bit to be desired. I think it's extremely  
235 high for a number of system types, and because we're limited to the choice of systems, it's very difficult to get something that's representative.

**IN: So do you think that in its current state, is Part L2A is adequate?**

I06: I suppose it's whether we're trying to, the aim of this procedure is to reduce emissions in buildings and I think that is actually happening because people are concentrating on, you know, improving buildings. As I  
240 said there are elements which are not really representative, represented that accurately, and that can cause problems, particularly when there's differences between different pieces of software. I can see how, I would've expected a dynamic simulation package to be better than SBEM, which is done on a monthly average, whereas the simulation is done on the hourly, an hourly calculation. But I would expect that for a very, very simple building, the results should be comparable, certainly with lighting and energy consumption should be  
245 identical and there will be differences with heating and cooling. It's the fact that I see differences between them means there's something in the way the software's been put together against this methodology that's not been published yet that's different. There's different assumptions being made.

**IN: Do you think that's an issue that should be addressed in the TM33?**

I06: Yes, it's fairly basic really the TM33. It didn't really, it validated software for routines and the way it took  
250 in the data and produced results. It didn't look at how the particular bit of software was actually, how it's produced the Part L results. It just looked at how, what the calculation routines were. So I think that's the main problem there. It's probably one of the things I could go on about. But I think that the idea is good, I think the, some of the features of the software are limited really and need some improvement, there needs to be consistency between the different pieces of software.

## Interview 07 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?**

I07: Right, this is a large retail development essentially. Somewhere in the region of 120,000 square meters. Comprising 8 buildings in a sort of linked development, plus 2 anchor stores.

5 **IN: Can you give me an idea of where it's located?**

I07: East London.

**IN: Can you briefly describe the systems that were used?**

I07: At the sort of macro-level, it's a CHP or Tri-generation, rather. Centralised heat, power and chilled water distribution, which serves the whole site. Each building has got its own heat exchange system which takes the heating into the building, the heating and cooling into the building. And depending on the usage of the space, it's generally fan coils, but some places have got chilled beams and large scale ventilation systems, so it's all air conditioned.

**IN: What were the main design criteria that were considered in this project?**

I07: One of the planning requirements was to achieve 10% better than Part L. And then there was 20% further improvement through the application of the Tri-Generation. Beyond that, there wasn't a great deal of drive. The developer was looking to minimize or keep the cost to a minimum.

**IN: So the 10% and 20% were the sustainability targets?**

I07: Yes, they were effectively imposed by local authority.

**IN: Which software did you use for this exercise?**

20 I07: We used Tas

**IN: Which version?**

I07: This would've been 9.0.9 at the time.

**IN: Why was this tool chosen? (Were there any influencing factors-financial...etc?)**

I07: It's the software we use in the company, exclusively for Part L. That was a decision we made when it was first introduced.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training....etc)**

I07: High.

**IN: How many years have you been using it for?**

I07: Two, two and a half, something like that.

30 **IN: Would you have preferred to use another tool?**

I07: Not for this job, no.

**IN: Could you briefly describe the process that was involved with achieving Part L2A compliance for your project?**

I07: Yes it's just following the standard procedure of modelling the building, taking all the available information; architectural, building elements, services design, parameters and putting them right into a model. Simulating, producing the output and testing it against levels whether we achieved our targets and reiterating in the cases where we hadn't to bring those within target and set what the design criteria needed to be to satisfy.

**IN: How were the different roles and responsibilities for each of the group members structured?**

40 I07: Within our company, effectively Part L assessment is treated as a specialist service. So you've got the engineers sitting in the centre doing what engineers do. And I sit to the side of them, getting their information and the design teams' information and putting that together in the Part L assessment. So, I'm really a group of one doing that work or working with others who have those skills. And the engineering team group, in this case, were maybe a group of 6 or 7 people working on all those issues.

45 **IN: And the interface with the architects was through?**

I07: Was through the engineers

**IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**

I07: The initial one would have been at stage, sort of between Stage C and D. We've been doing iterations as the designs have developed since.

50 **IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**

I07: In order to meet the rapid turn-around, we had to outsource some of it. So we went to EDSL Consulting to get some of that done. Everything else was (us), they did a couple of buildings I think and everything else was done internally using available members of staff to do those.



- 55 **IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**  
 I07: Well they gave us quite short notice of turn-around and everything else, but that aside it was the right point to be starting to do the analysis, to bring it in. And so it was the right point in time for that to happen.
- IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**  
 I07: Varies considerably depending on the size and the complexity of the buildings, but I generally work on an  
 60 average of about 5 to 6 days.
- IN: Full days?**  
 I07: Yes, that includes reporting and producing a deliverable, not just doing the computational side of it.
- IN: How did this vary from the time you initially planned to spend?**  
 I07: Since that's roughly what I'd allowed, it didn't. But other, some elements of it longer, some elements took  
 65 less time. So it probably overall balanced out. But in revisiting some of the parts, because the buildings have been evolving throughout that period. So rather than just being able to take that into the model, we've had to start some bits from scratch again. So we've seen that overall time spent has probably been more than we would've liked.
- IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**  
 70 I07: Generally we were pretty close to meeting the targets, if everything wasn't, we were able to respond with things like lighting levels or lighting efficacy rather, maybe toying with some of the specific fan powers.
- IN: That was my next questions actually, so you changed parameters like lighting and fan power to achieve compliance?**  
 I07: Yes.  
 75
- IN: Which Input parameters did you observe as having the most affect on your results?**  
 I07: Generally I find cooling and lighting to be the most, well the largest carbon emitters and therefore the ones with the most bearing on the results.
- IN: This is for this project or in general?**  
 80 I07: That is general, certainly where it is an air-conditioned building. Obviously if it's something different, then it can quite be different from no cooling, it's not there it's not going to be a contributor.
- IN: Describe (approximately) the variability in results that was observed (in percentage).**  
 I07: Depends what you're doing and how much improvement you're looking for. And therefore you kind think how much do I need to make it to meet that, whatever shortfall it is. The more the shortfall, the bigger  
 85 the change you have to make. But achieving a sort of variation of 5 to 10% improvement can usually be manageable.
- IN: How did these results feedback back into informing the building design process? (or was is separate?)**  
 I07: At the end of each assessment we prepare a report which says based on this set of parameters, this is the improvement over Part L that's been achieved. So that sets out exactly what we've done and what we've had  
 90 to do to improve things and through that it goes back to the design team. So this is what you need to do, because that's the Part L in completing your design.
- IN: And that's with regard to the architectural and the HVAC?**  
 I07: Yes basically, yes.
- IN: Are you formally accredited to carry out Part L2A compliance calculations?**  
 95 I07: I'm an LCC simulation and design.
- IN: Did you use any internal methods to assure quality control and the validity of your results? Please describe these methods.**  
 I07: We have an internal policy which says everything must be reviewed before it goes out of the office by somebody who's not done the work effectively. So in theory everything that I do will be reviewed by  
 100 somebody else who's suitably competent to review it, with experience in Tas and it will be authorised by the person leading the project to say 'yes, I'm happy for this to go out of the door'. So yes, there is a system in place.
- IN: So was the work submitted on your behalf to building control?**  
 I07: It hasn't because we haven't got to that point yet in the project. However, I have been involved in some  
 105 meetings with building control to spell out some of the concepts of what we're doing to advise on those. Because it was such a large scheme, we wanted to make sure the way we were tackling it, they were ok with that.
- IN: So you had regular meetings with building control?**  
 I07: Yes

110 **IN: And what impact has this had on your work?**

I07: Not considerable because ultimately that said 'yes, we get what you're doing it's fine and suitable'. But we did that before we started to make sure that we weren't going back on ourselves.

**IN: So their impact was minimal at this point?**

I07: Yes.

115 **IN: What are the main issues, if any, did you encounter during the simulation process? Please describe these issues.**

I07: Right. Yes, there's certainly been multiple issues encountered. In general it's been all software based things. So you're trying to do something, how to actually model a system which in reality is doing something quite complicated with something that is rigidly defined within the software. So for example, in the retail section of the building we had supply air going into the main mall then being extracted via the retail units, which there's no simple way of actually modelling in any of the pieces of software to account for the energy transfer that that incurs. So we've had to make sort of judgements and so on what best reflects what's actually happening. In energy terms it is going to be consistent with what we would actually see. So it's more about the limitations of the program constraining you to have to solve another set of problems in terms of how you actually being reality into the domain of a piece of software.

**IN: You mentioned that you used Tri-gen and, well CHPs, was Tas able to model that properly?**

I07: We didn't actually have to incorporate that because the planning requirement was go to 10% better than Part L, then do Tri-gen. So we were just demonstrating that we'd gone 10% better than Part L through the impact of design based measures, energy efficiency and passive design features rather than enhanced technologies.

**IN: So did you have any problems with the actual methodology or applying it?**

I07: In principle no. I'm comfortable with what the methodology is trying to do and the basic system that's in place for doing that. Where it falls down is where you've got real world systems which aren't rigidly defined in the way they are in the regulations. You have to say 'well where's my system boundary, what's actually happening here, where's the energy flow, what's, how can I model that in a way that that can understand it'. And that is really sort of the main place where you have all, where all the issues arise.

**IN: So it's basically tool limitations and modelling systems in a way that is realistic?**

I07: Effectively, yes. So you're not oversimplifying while you're actually trying to solve something because you've got a reason for doing what you're doing. But the other end, you can't always bring that into the computational model of that.

**IN: Which would you regard as the main priority for consideration in future Part L2A revisions. How would you recommend that these issues be dealt with?**

I07: Yes I mean, that's the real stumbling block is, you know with obviously they've had the time limitations and the amount of flexibility that they can introduce just from a programmer and developer point of view. So I don't begrudge them doing what or doing things and the way they've done them. Anything that can be done to introduce a bit of flexibility for the designer in the way that they can model their designs is going to be advantageous in terms of producing more realistic results.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

I07: I think it's reasonable as it stands. I mean a program like Tas is not perfectly suited to Part L, because of the way it works you have to do multiple inputting of data in different modules to get it to create something which you can then analyse as a Part L model. Whereas with something like SBEM, you just do it once, press a button and everything happens. If there was some way that you could put the Tas calculation behind a simplified SBEM type interface or iSBEM interface, then that would certainly help. But I don't think that that's going to happen because of what Tas are doing anyway.

So it kind of, sort of gets to a point where you're saying 'well there's a program that exists which they've modified to meet the needs of this, and there's a programs that been created specifically for doing this. So do you take the one that's specific to it and then have to do something else to do you other needs or do you take the one that does everything and accept that there's a bit a extra effort involved in creating an unknown?'. And at the moment I think we'll probably stick to the extra effort. I think they can improve the program by making it a bit more user-friendly, but there's always going to be a premium associated with that in time.

My more overriding issue recently, they've just finalised the notional building definition which has come out in the latest release of Tas, the 9.1 and has had a significant effect on the actual results you get out with it. Which has meant that all the hard work we've done in the past, could be potentially jeopardised by the fact that where we were showing good improvements before, they now have got massively reduced. So now

165 possibly, in some projects, go back and make further improvements to elements where previously everything was ok. That really takes it back to the top of the tree saying this information was needed far earlier and the fact that it's been two and a half years, best part of, in coming around, has caused considerable more heartache than it really should've done and being there at the kick-off and knowing what they were working with rather than having to kind of pick up the pieces as you're going along and moving a goal post every few months.

170 **IN: Are there any other issues you'd like to discuss?**

I07: That's really the main one.

## Interview 08 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?**

I08: It's luckily (name ) Building. It's a, about a 250 square meter footprint school near Reading. It is using a ground source heating and cooling, coupled with underfloor heating. Do you want this level of description now?

**IN: Yes.**

I08: Coupled with underfloor heating, heating and cooling coils in the mechanical ventilation, which also has heat recovery. It is, we've gone for high U-Values to try to and meet the TER.

**IN: What were the main design criteria that were considered in this project?**

I08: There's been no specific design criteria as in the carbon cutting on the job that we've been doing to meet building regulations, but the client has got aspirations to put money in the project to reduce their emissions.

**IN: Did you have certain sustainability targets?**

I08: No, just to meet the building regulations, no specific other targets were set.

**IN: Just Part L then?**

I08: Yes.

**IN: Which software did you use for this exercise?**

I08: IES VE.

**IN: Which version?**

I08: Not quite the latest one.

**IN: 5.8?**

I08: Something like that, I don't know.

**IN: Why was this tool chosen? (Were there any influencing factors-financial...etc?)**

I08: It's what we generally use in the office and also I needed to do thermal models on the building to check out the heating calcs. So the model was always going to be created anyway in that program. So it made sense to use it for the Part L model as well.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training....etc)**

I08: As far as Part L calculations are concerned, I've done, this is the fourth model that I've done that has passed. Well this one's not officially yet, but it's passed the Part L. I've done other models on it thermal and daylighting.

**IN: How long have you been using IES for?**

I08: I had my introductory training to it a bit over a year ago now.

**IN: So it was formal training?**

I08: I've had one formal training session which was two days in this office here with just a few of us going through the basics of creating models and a little bit on thermal modelling as well, I think we did.

**IN: Would you have preferred to use another tool?**

I08: Other than SBEM, which I don't really know how to use, I'm not really aware of any other models and how to use them. So, no.

**IN: Could you briefly describe the process that was involved with achieving Part L2A compliance for your project?**

I08: What do you mean exactly?

**IN: Just give a brief description of the steps you followed or people who were involved.**

I08: Ok. So we obviously used the architects plans and constructions to create a model of the building, a 3D model of the building. The U-Values and all that information into the model, then set the system types according to what we had designed as a company-pretty much just me working on it. There's a partner in charge who's had some input. So I put all that information into the model, ran it and it was pretty simple to be honest. It passed pretty quickly.

**IN: How were the different roles and responsibilities for each of the group members structured?**

I08: Within this company?

**IN: Well generally, and within the company.**

I08: Well within this company, the project is, I'm the project engineer on it, there's a partner in charge, but pretty much because I've done work on Part Ls before, I've been left to do it myself. And it's been solely up to me to get any input I've needed to put into that model from the architect, hardly needed any from the structural engineers, it been pretty much just been from the architects. Then certain feedback that's then come from that then needs to be put back to the design team meeting to let people know for instance we're looking

- 55 at the glazing requirements in certain rooms to minimise solar gains- which is criterion 3 of the Part L. And that, then I was able to say what we required after we made the model. So mainly I just gained information off the design team members I needed and then put back information as I went along.
- IN: So you were solely responsible for the simulation?**
- I08: Yes.
- 60 **IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**
- I08: Part L was done just before Stage F. So just before tender.
- IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**
- I08: No. I have spoken to, I've spoken to the technical helpdesk at IES before on other projects. But this one is much smaller than other projects I've done and simpler. So I don't think I needed to at any point on this.
- 65 **IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**
- I08: I think on a small project like this it probably, it was fine. Obviously there's certain impacts it can have on building materials, costs, building systems and I think on a larger project you'd want to probably model it earlier to be aware of that. But on a building of this size it was ok to do it at that stage. But maybe on a larger project you'd do a preliminary model and then do your final model now. Because things are always going to change as well.
- 70 **IN: So you would have preferred if it was larger to go for an initial assessment?**
- I08: I think I would have preferred to at least even if not submitted to anyone or just done it for myself at an earlier stage so it would've brought up any of the issues that may have well come up and I could be aware of them in a design team meeting and just brought up any issues that could affect the building.
- 75 **IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**
- I08: 20-25.
- IN: How did this vary from the time you initially planned to spend?**
- I08: Probably about right, about the same. I mean you always plan for a little bit extra in case it doesn't work.
- 80 Because these models can have little glitches which you can't really understand at times. So it's always hard to define a time for doing a model because silly things can catch you up, but on this occasion nothing went unexpectedly wrong and it took that time.
- IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**
- 85 I08: Yes, I never had any problem, not achieving, not compliant. But I didn't try and run it straight away. I knew what I wanted to put in. I put that data into it and ran it, rather than just making the basic model then running it.
- IN: Which Input parameters did you observe as having the most affect on your results?**
- I08: The U-Values in this case.
- 90 **IN: So the building envelope?**
- I08: The building envelope. We'd always aimed to reduce the U-Values to pass, to meet the TER. So that made a big difference. And then in this case we're using a heat pump, so the heating and the cooling systems are both very efficient. So that straight away gives you a, that helps to pass straight away.
- IN: Describe (approximately) the variability in results that was observed (in percentage).**
- 95 I08: On this project? Well U-Values, obviously the TER is however much- 20% or what have you improvement -over the BER and the U-Values set out in Part L are at least over Part L. If you just increase them by 25% you automatically reducing your heat losses and gains by that much. I mean that has, that has a direct obvious effect and then the heating systems. I mean a heat pump is just, it's an efficient, it's easy to show how it's an efficient heating system and again it improves your, it lowers your carbon emissions. So what-say that question again.
- 100 **IN: What was the variability in results you get by changing these parameters? Estimation in total reduction you get.**
- I08: 0-25% difference. The final model was I think 35% better than the BER so, was it maybe 30%, so that all comes from those changes.
- 105 **IN: How did these results feedback back into informing the building design process? (or was is separate?)**
- I08: As I said earlier, the main thing that we were looking at was the G-Values for the glass. So the amount of solar heat that comes into the rooms for overheating, so I was then able to advise what G-Values were needed on the glass.
- IN: That's the architect?**

- 110 I08: To the architect. Then I mean the others, the systems we set knowing that they were efficient systems and none of them needed to change, so there was no other real changes that came after the model was built.  
**IN: Are you formally accredited to carry out Part L2A compliance calculations?**  
 I08: I've not gone through any formal.  
**IN: What route did you follow to submit your work?**
- 115 I08: I've just submitted it to building regulations or through to an assessor, building regulations assessor and they ask whether you're a competent person I think is the question. I've been trained in it.  
**IN: Did you use any internal methods to assure quality control and the validity of your results? Please describe these methods**  
 I08: The submitted document was looked through by some people, by the project engineer or the partner in charge for instance but other than that not particularly. More so on other jobs that I've done that have been bigger, so.
- 120 **IN: Did your building pass with regard to the requirements of building control**  
 I08: I've submitted it, but I haven't got the answer back yet.  
**IN: Did any of your team have any contact or interaction with Building Control?**
- 125 I08: I've spoken to them as how they want us to submit all our information and that's it. I've had a few little queries about things which I've just brought up with them over the phone, but nothing major, no.  
**IN: Please describe this interaction (how, when, method, impact)**  
 I08: No, not on this occasion.  
**IN: What are the main issues, if any, did you encounter during the simulation process? Please describe these issues.**
- 130 I08: No.  
**IN: With regard to Part L2A, have you had problems with other projects?**  
 I08: With passing?  
**IN: Passing or applying the methodology.**
- 135 I08: I've done models for leisure centres before and with the more complex systems that you've got in a leisure centre, for instance the systems associated with the swimming pool, it was kind of quite a grey area on how to apply that to the model because the energy used in a swimming pool is kind of a process load it's kind of, it's not clear or not if its covered in the Part L or not, and if so how to include it in your model. So that was more difficult and that took interaction, I spoke to the building control officer in charge of that and we got a response from them. But again it resolved itself and it wasn't an ongoing problem.
- 140 **IN: Have any other issues come up with regard to the capability of the tool that you were using?**  
 I08: Depends what you, how you see it. If you just see it as a way of passing building regulations, then it's not been a problem. I've been able to pass and have felt that the figures I put in have been fair, but you don't feel it quite covers everything it needs to. I haven't had any problems with it, no.
- 145 **IN: With regard to that point, was it an issue of not being able to model for instance, or being able to accurately model systems?**  
 I08: Sometimes it's not quite clear how to model a certain kind of system and you might make a compromise and say 'well I'm going to model it this way though I'm not quite sure that's exactly right'. But you can't let yourself get too bogged down in that. So obviously it's not as meaningful a result the answer you get out, but at least it's a way of comparing project to project, even if the actual figures you're getting aren't really going to be the case, it does make every project conform to a sort of, well, a regulation. I think it's pretty, I think it's worthwhile. If it was to be moved on and continued to, kind of more detail.
- 150 **IN: Which would you regard as the main priority for consideration in future Part L2A revisions. How would you recommend that these issues be dealt with?**
- 155 I08: I think it's the, it's coming back and making sure what you've designed is actually the case, I suppose. Making sure that what people said they were doing is actually the case once the building's been built. I know it's part of, you're meant to submit, you're meant to redo the model at the end of the project with any changes that have been made during construction. I suppose it's some way of measuring the figures you've come up with in your model with the actual figures of the building actually runs a year later or what have you and I don't know how you do that because your building doesn't actually run with the NCM templates with the profiles all set up in the modelling process. But some way of quantifying how much energy, CO<sub>2</sub> the building uses and comparing that back to the models would be very helpful.
- 160 **IN: In summary, how would you assess the overall procedure and how do you see it being improved?**  
 I08: Like I just said, getting results afterwards. I mean the thing that is most annoying is little glitches in the

165 actual IES software, it's just a bit clunky and difficult to use. But any, it's a pretty complicated program so you  
can understand that. But if that becomes user friendly, if the systems are all a bit defined slightly better and  
the figures are a bit more see through and understandable where they all come from, I think it's a fairly good  
process

**IN: It's things to do with the tool rather than the methodology or the regulations?**

170 IO8: Yes, the regulations need to be clear where everything is coming from in the tool. So it needs to be clear  
why you are doing things, which there's certain documentation that helps with that. But the more clearer the  
better, I suppose.

## Interview 09 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?**

I09: Recently, one of the projects I've worked on most recently is a project which, it's a residential house in the north of England, just off Grimsby. And, but it's quite big, and slightly unusual in I guess how we tested it for Part L.

**IN: This is Part L2 or Part L1?**

I09: Yes it was, that why. Well, it's normally you would use Part L1 for a house. Well this house the floor area was in excess of 3000 square meters, so we actually, we actually contacted building control and agreed with them that Part L2 would be better suited. Yes, so we used Part L2. And it was slightly unusual in that the house was located in the middle of nowhere. It was some sort of nature reserve, so the whole, the main constraint on the planning was that we had to provide 50% of its energy had to come from renewable or low carbon sources,

**IN: So where was this located?**

I09: Grimsby, north of England.

**IN: So what sort of systems did you use?**

I09: There was a, I didn't actually design the, I wasn't involved in the design, I was just doing the Part L. So the project, was I was given the all information and plugged it into IES. But yes, the main heating system was done via heat pump and a biomass boiler. They were working both meeting 50% meeting the demand for heating.

**IN: So 50% was the sustainability target for the house?**

I09: It also had a solar thermal array which was sized to cope with 100% of the hot water demand. Its oversized by a long way and it, we used a lake outside of the house to dump the excess heat into. I think they've now have downsized it slightly since the original design, but it's still quite a big solar thermal array. I can't remember the exact square meterage

**IN: Which software did you use for this exercise?**

I09: It was IES.

**IN: Which version?**

I09: 5.8.1, I think.

**IN: Why was this tool chosen? (Were there any influencing factors-financial...etc?)**

I09: Well, it's the best method for showing Part L compliance that we probably know at the moment. It's the most user-friendly. I mean SBEM would've been a nightmare to do that building in.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training....etc)**

I09: I've done a few projects, but I haven't, I've been using it for about one and a half years. So I've got a fair amount of experience.

**IN: Did you receive any formal training?**

I09: I did go on a course. Well, it was a telephone course that happened over the phone. A telephone conference type of thing. We had a person from IES who directed the entire thing and she gave us the initial training. And from there on I, I learned most of what I do by phoning IES and asking them directly, I guess.

**IN: Would you have preferred to use another tool?**

I09: This question is slightly, I've been thinking about this. Because yes, of course, if there was a better tool I'd prefer to use that.

**IN: So any tool in particular that you know of?**

I09: I don't know of anything better, but I can easily imagine a tool that would be better than IES. Because IES is not perfect by far.

**IN: Could you briefly describe the process that was involved with achieving Part L2A compliance for your project?**

I09: I don't really know what you mean by that question.

**IN: Just a brief description of the project, the steps you followed, the people who were involved.**

I09: We knew the project was slightly unusual, but there's actually a clause in Part L1 that says the SAP calc only applies to dwellings with a floor area up to 450 m<sup>2</sup> or something, and this house was 3000. It's a big dwelling so I decided to phone the building control and ask them directly what they wanted us to do. So what they said, they said they'd rather we use Part L2. And we classed the house as a hotel. So we modelled it as a hotel, not a house. Because there was, the way Part L2 works, they have the different profiles you assign to the different spaces. If we, I mean you have to choose a building type which we have the right types of spaces for



- 55 what you're trying to model. Things like bedrooms, you know you have a kitchen, a bathroom a bedroom. A school will not have a bedroom so you have to do, the hotel was pretty much the only one that fitted the description, I think.
- IN: So where did you source the information?**
- I09: The information, it was mainly the engineers who worked on the project here. We had, I mean obviously
- 60 we had the architect's drawings and details, I didn't actually have direct contact with them.
- IN: How were the different roles and responsibilities for each of the group members structured? At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**
- I09: Stage E. I think Stage E is quite late.
- I0\*: But you did a spread sheet first though?
- 65 I09: I did a spreadsheet in parallel.
- I0\*: Not early on.
- I09: No
- I0\*: No one did one?
- I09: No.
- 70 **IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**
- I09: Not really.
- IN: So you didn't have any help from the IES technical helpdesk or anything?**
- I09: Not, well, no I don't think so.
- 75 **IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**
- I09: Again, that's difficult to answer that because it depends on the project, I think. For example some projects are, it depends on how much the project is, the building is likely to change from one stage to another. I mean obviously, the earlier you start, the better.
- IN: So specifically for this project?**
- 80 I09: I think for this project it was probably about right.
- I0\*: We prefer for people to do the spreadsheet very early on because it doesn't require detail. The information available at the time [early on] is insufficient, so you could leave yourself go very far down the line without knowing whether you comply or not (because you can't carry out the calculation early).
- I09: I mean for this project we were never concerned about it failing, because we had so many renewable we
- 85 knew it was going to pass from day one. So actually, it doesn't really matter. We fulfilled the planning condition of 50% and be met by low carbon sources and building control people agreed with that. So, and that in itself was more than enough to pass Part L.
- IN: But it general you would prefer to undertake Part L earlier on?**
- I09: I had some experience in projects where I took them on, I took them on at Stage E and sometimes even
- 90 after tender and I realised that actually the building was failing and it was very difficult to make any changes obviously by then. So yes, there is, I think it varies from project to project but generally I think Stage D would probably be.
- I0\*: Yes, there's some designs you don't have the information required by Stage D to put in, but if you don't do it by then, you know, you could be stuffed.
- 95 **IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**
- I09: In terms of hours?
- IN: Yes.**
- I09: 100, about 100.
- IN: How did this vary from the time you initially planned to spend?**
- 100 I09: I think it was about right, that's what we had expected.
- IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**
- I09: Yes. It's an unusual project in that sense. That doesn't normally happen.
- IN: Which Input parameters did you observe as having the most affect on your results?**
- 105 I09: Again, that's a very difficult question. Because this project we haven't actually haven't played around with different parameters because it passed early on. But we haven't actually done a sensitivity study to see which parameters had the biggest effect. I mean things like you know the boiler efficiencies is great. If you had a boiler that's 99% efficient then you pass, no problem. But that's not possible so it depends upon what you can realistically achieve I guess. We have tried, on that part of the project, we tried altering the lighting, because

- 110 that is something you can change quite easily, you can introduce controls to limit your power consumption.  
**IN: That's in general or for a specific building type?**  
 I09: I guess that's with regard to a specific building type. I mean it depends on what you're working on I guess. It's not always possible to play around with the lighting, but on some projects it is. On other projects it's the auxiliary energy so you calculate, I mean for example on (project name), I calculated my own auxiliary  
 115 energy because I was, my building was, my pumps and fans were using a lot more than the notional building. But I knew that our equipment was quite efficient, so I set up spreadsheets where I listed all the pumps, the boilers, the power consumption I added some diversity factors, because you know they're not going to be running all the time and I calculated an average value per square meter and applied that to all the systems. And that helped.
- 120 I0\*: But are you allowed to enter those or did you just put it in the ( )?  
 I09: You are allowed to. No in IES you could always change that, I think. When you define your system, you just put in the auxiliary energy. In SBEM you can't and that's a real pain, but in IES you can.  
**IN: Describe (approximately) the variability in results that was observed (in percentage).**  
 I09: I can't remember, I couldn't tell you.
- 125 I0\*: But it could be the difference between a pass and fail?  
 I09: Well it could be certainly. Normally, it's only a few percent up or down. I mean you obviously want. I can't remember, I can't remember the figures and to be honest, I never looked at it to see what. Because when you work on a project and you have a deadline to meet and it's a lot of pressure for you to pass a building you kind of tend to not, you just try to make little changes and you lose track of what difference they make. So I  
 130 can't answer that question.  
**IN: How did these results feedback back into informing the building design process? (or was it separate?)**  
 I09: I wasn't really, I don't, I guess so. I'd like to think so.  
**IN: Are you formally accredited to carry out Part L2A compliance calculations?**  
 I09: I don't think I am. Am I?
- 135 I0\*: You're not, but we have people who [are qualified to] sign off.  
**IN: So that is the route you would follow to submit your work?**  
 I0\*: Yes, I mean we can't have everyone trained. There's a whole raft of courses, that cost loads of time and money. So we just, we have a few people [accredited].  
 I09: I'm signed up for one of the later courses, the EPCs and things.
- 140 I0\*: Are you?  
 I09: I think so.  
**IN: Did you use any internal methods to assure quality control and the validity of your results?**  
 I09: There is no, I don't think there is any framework in the practice but I obviously I always consult the people, the superiors, and tell them what my assumptions are. And I speak to other people in the office who  
 145 run IES to make sure I'm doing things right. But there is no formal process in place.  
 I0\*: Not for the simulation itself. There is [a simulation reviewer], when you start doing simulations. For the first two - someone will review them.  
 I09: Do you have to be accredited to submit?  
 I0\*: For EPCs, yes.
- 150 I09: For example, on (project), we just sent out the print out from IES and the building controller said that he was actually going to come and see the model himself. But he wasn't, he didn't question the fact that I wasn't certified or whether I was certified.  
**IN: If they regard you as being a competent person, they can just pass your work.**  
 I09: OK.
- 155 I0\*: You've done the IES, you've got a CPD certificate haven't you?  
 I09: Yes.  
**IN: So it's basically up to the building control officer in this case.**  
 I0\*: Yes, it's not like the EPCs where you actually have to have people to sign it off.  
**IN: Did your building pass with regard to the requirements of building control**  
 160 I09: Yes it did. But I'm not sure again if I understand that question.  
**IN: Did you submit it and did it pass?**  
 I09: Part L wasn't, the (sub farm) wasn't submitted yet because the, it's a performance specification. Did you know about that?  
 I0\*: Yes, so we're saying it will pass unless [it changes] when you carry it forward and [then] it's the

- 165 contractor's responsibility.  
 I09: We designed the building up to Part E, up to Stage E and the contractor who takes over and does the final design.  
 I0\*: Design and build. [This is a particular procurement route]  
 I09: So we passed the model onto them and they have to then do the final submission.
- 170 **IN: Did any of your team have any contact or interaction with Building Control?**  
 I09: At the beginning to find out what methods I was going to use to show compliance.  
**IN: Please describe this interaction (how, when, method, impact)**  
 I09: I sent them a letter saying this is what I want to do, that's what we've agreed unless you contact me and say otherwise, that's what I'm going to do. And I went along that line of calculation.
- 175 **IN: What are the main issues, if any, did you encounter during the simulation process? Please describe these issues.**  
 I09: This question which one is that?  
**IN: Its number 16**  
 I09: One problem that I found, I mean this relates to the method in IES in particular. I found the framework really restrictive in the fact that you couldn't simulate a house which has a floor area of 3000 m<sup>2</sup> I think. Ok, it's an unusual case but it shows that the framework that's being used to show compliance is really inflexible. I mean I guess this is an isolated case but for example, I'm working on a school now where we have radiators in classrooms and fan coils for cooling and you can't simulate that on the Part L. You can only have a room with radiators or a room with fan coils which do both cooling and heating, but you can't have a room with both. I think that's really poor. On South Farm, we simulated it as a hotel and we ended up with carbon emissions which are equal to big theatre buildings with, you know, shops and the restaurants within them. They are nowhere close to what the actual building emissions are going to be. But in some sense that doesn't matter because what you're trying to show is the performance of the building with respect to the notional.
- 185 **IN: So they were both high?**  
 I09: They were both high, yes. So our building still passes by a long way, but it has nothing to do with what the actual emissions are going to be. I think that's sort of, it's not right. It should be at least sort of, at least should be hitting the right ballpark, you know.  
**IN: So did you have any problems with simulating or modelling the systems using IES?**  
 I09: On this project yes. It was quite tricky, but I think I got through most of it. I created my fuel type for the, because well it's very difficult to compare two systems running parallel. We had the heat pump and the biomass boiler and they run, the way the system was designed is that both systems run together and so they both run on different fuels with different carbon intensities. So I just had to sit on my own and had to do a hand calc and calculate exactly what carbon emissions this system would generate. And I set up, I calculated my own fuel type which then I then applied to the system and I called this, I created a whole new system. It wasn't a boiler, it wasn't a heat pump, it wasn't using electricity, it wasn't using gas, it was using my own type which gave me the emissions I calculated.
- 200 **IN: And that was the only way you felt you could accurately kind of represent the system?**  
 I09: But it was possible using IES.  
**IN: It was possible, but more complicated?**  
 I09: Yes, but I would expect it to be because the project was unusual. The fact that I could do it was quite useful.
- 205 **IN: Which would you regard as the main priority for consideration in future Part L2A revisions. How would you recommend that these issues be dealt with?**  
 I09: Which question is this?
- 210 **IN: 17**  
 I09: 17, it's a difficult one to answer. I would certainly try to increase the flexibility of the calculation method. This whole idea of drop-down boxes and picking, you know, it's useless, you know, you have a whole list of different types of profiles you can use and you can never get them all the way you want. It like the example with the radiators and the fan coils. Sometimes there are projects which are unusual in the way they are controlled. But again it's really difficult to say how you would fix the problem. How you would actually do it. How you'd make it more flexible.
- 215 I0\*: ()  
**IN: But then of course you'd get variability because of the different way people will approach it.**  
 I09: And then you have a whole list of assumptions which you made, which you then have to submit to

- 220 building control. It's just a really tough one. It's difficult to criticise the government for making it the way it is.  
 IO\*: I think you can.  
 IO9: It's not ideal, but it's really difficult to think of a way of making it ideal.  
**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**  
 IO9: Convoluted, that's the only word for that. And I don't know how I would improve it, to be honest.
- 225 **IN: So you think the methodology is not straight forward, it's not as clear as it should be?**  
 IO9: Possibly. I guess to do it would be to certify some people, to make sure there is a framework to get people certified to make these submissions. Once that's done they should have the flexibility to simulate the way they like and they shouldn't be questioned. Once someone's certified they've been tested by a body, an organisation who gives them a stamp saying they're ok. From there on it's almost, I think it's almost like they should be able to simulated the building and not be questioned from there on. It very difficult, but
- 230 IO\*: If you're competent to design a building you should be competent to simulate one.  
**IN: Yes. You mentioned earlier when I asked you about if you would prefer to use another tool that you do not know of a better tool, but you do know how you'd like the tool to be improved or what a better tool would include. Can you give me an idea about that?**
- 235 IO9: Well for example, IES is ok but it's got too many bugs in it. There are little thing that if you don't know about, you're going to get things wrong and it's just that the whole interface is slightly more complicated than needs to be.  
**IN: Can you give me an example of the bugs you mentioned?**  
 IO9: Well for example.
- 240 IO\*: I've got the list. They change with the upgrades. They bring out upgrades rapidly and they don't tend to [test and de-bug] it.  
 IO9: There was one project I think when David comes in after me he'll talk about where we changed the version of the software throughout the project, and the new version of IES gave completely results. We thought our building was passing all along and then the new version came along and I think it failed something. And I ran the same model on a different version and I just converted it. There's a, you know, you start the new version and it asks you if you want to convert the model and you say ok. It backs up, you convert the model to the new version and it backs it up and then runs, And when I got my results and they were all different, I thought well actually I'd rather use the, carry on using the old version. I wanted to go back to old version, the old model. So I went to see, to look at the backup and it backed up the new model. It overwrote the old one and backed up the new.
- 250 **IN: Can I ask did it not pass because the notional building differed or because the results from your actual building were different?**  
 IO9: I think they were both different.  
**IN: They were both different, the notional and your actual building even though you didn't change anything?**
- 255 IO9: Yes, because the NCM profiles were changed by the government. And at the same time IES released the new version, so they kind of both, it was really, really weird. And I asked IES, I phoned them up many times asking about this, and eventually they said don't worry about it, it's fine, because we got it to pass eventually and they just said, they couldn't explain the differences. They just said, you trust us, basically.
- 260 IO\*: We don't. With upgrades, we have had them where they overwrite your previous database forever, which threatening to the integrity of you simulation. You should actually keep [all revisions across] versions. There's a lot of problems with that.  
 IO9: But there are various things like you know, there are various places where you enter several parameters. For example, things like permeability of the building, you enter it in the, do you know IES, do you use it?
- 265 **IN: Yes.**  
 IO9: In VE Compliance, if you use the building systems button and click on that and the window comes up where you enter different things like the building address, our address, our name and stuff for the company and they ask you for things like the power factor and the permeability, but these values that you enter in there don't actually influence the simulation in any way. You just enter the, They're the ones that get printed on the BRUKL output, but they have no influence on what the model actually does. So why do you put them in? But the power factor might have an effect on the outcome of the simulation, but it's not huge. I've tried it by changing it and it hardly does anything to the results. But the permeability, there is a separate, you define it in a separate, in each of the templates when you select.
- 270 **IN: In Apache?**

275 I09: Yes, you don't have to be in Apache to do it, you can do it on the top menu. You can go to template.

**IN: Where you can define your building.**

280 I09: Yes, and there you put in where you select your heat gains and things, you put in permeability and infiltration and again this is something that has changed. Because it used to be 0.167 or something in one of the original versions and I find IES saying many times it's not enough. Under normal conditions, in a room like this you might get two air changes per hour, maybe one. And they were saying 0.16 is what we should be assigning to our buildings. And I phoned them up saying its wrong and they said no, no it's right, without the calculations it's correct, that's what we say it is, that's what it is. And then which each consecutive version they kind of took it up a little bit higher and now it stands at 2.5 or something. But, it's just things like that you know. If you run your version, if you run your model on a previous version, it uses different infiltration rates.

285 Unless you spot it, unless you spot that's what they've done, it's really difficult to see where your differences have come from.

## Interview 10 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?**

I10: Well, before you said that I chose (name) School in Barking, which is a secondary school, 2000 people. So it's quite a big secondary school. But I had just chosen that because it was the most recent one I've done. And it's a fairly standard construction but it's got a ground source heat pump, gas boilers and chilled beams for cooling as well.

**IN: What were the main design criteria that were considered in this project?**

I10: That's a difficult question really. The only, the only real one, I think is probably just comply with the building bulletins and the regulations. I don't think there was anything really, there's nothing over and above that.

**IN: Did you have certain sustainability targets?**

I10: No.

**IN: Just building regulations?**

I10: Yes.

**IN: Which software did you use for this exercise?**

I10: I used IES.

**IN: Which version?**

I10: 6.8 I think? No? I can tell you, I can get back to you on that if you want. I can tell you when it was, it was about 3 months ago.

**IN: It was probably 5.8**

I10: So 5.8, yes, maybe that was it.

**IN: Why was this tool chosen? (Were there any influencing factors-financial...etc?)**

I10: Because I've used it before and as far as I know at the moment in the office, we haven't used an awful lot of other things.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training...etc)**

I10: Proficient. I know what, I think I've got quite a good idea of how to build models now. And it's only when it gets quite complicated that it's, that I'm not sure how to do things.

**IN: So have you had formal training?**

I10: I have had a 3-day, a 2-day course on Part L2.

**IN: Would you have preferred to use another tool?**

I10: I haven't tried to use any other tools, so I'm not sure, but I would say I would certainly like more flexibility if it was possible.

**IN: Could you briefly describe the process that was involved with achieving Part L2A compliance for your project?**

I10: Yes. Basically, I, we'd just put all the geometry in and then put all the windows in and the window opening profiles and things and then put in all the systems and the templates. And then I'll run the model and see what it comes out with and then if I think something's wrong somewhere, I'll check all the graphs and things and if I think something's wrong somewhere I'll go back to all the profiles and systems and things and try and make sure everything is working how I'd expect it to.

**IN: So how did you source the information you used for your model-architectural and systems?**

I10: With the architectural stuff, it was taken from their drawings and their drawings because this was done at Stage D, so we had proper drawings. And then the model was built from that. And then the systems, manufacturers data where possible and otherwise if I could find some kind of standard or guidance of it, I'd use that.

**IN: So were the engineers involved in helping you determine your systems?**

I10: Yes, there's several, there's several people kind of working on it. But actually probably, I knew what kind of systems. I know what all the systems are. So it generally was more of collecting information than actually, consulting.

**IN: So you mentioned that this was undertaken at Stage D?**

I10: Yes.

**IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**

I10: No. But that was because we had full information, we had all we needed from the architect already. So you might have to say that's co-operation. But apart from that no, nothing else.

- 55 **IN: So you didn't require any help from the technical helpdesk or anything?**  
 I10: At IES? Yes, I think I did phone them a few times actually. I didn't think of that.
- IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**  
 I10: In a way yes. But in a way it would also, I say yes just because if you want to actually prove compliance, you have to have, I think you have to have the building in a fairly finished state you can't really change things
- 60 too much afterwards. And changing things in IES is really difficult. Although, it might be useful to do it earlier, it's not practical, it has to be basically designed before you can really do it and then maybe you can tweak things.
- IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**  
 I10: I think it was about a week, so 40 hours.
- 65 **IN: How did this vary from the time you initially planned to spend?**  
 I10: I think I expected to take about a week because I've done them before.
- IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**  
 I10: Not the first time I pressed go, but it was quite quick actually. It wasn't very long. So what I would do is that I'd run it once and then try and check everything and see if everything is working how I'd expect it to. And then if it is, then that's good.
- 70 **IN: If not, what kind of measures did you use to achieve compliance? (Design changes or input parameters) Did this involve changing or altering the input parameters? Which input parameters did you alter?**  
 I10: I can't remember to be honest, but I didn't change any, I didn't change any of the design. I only changed how it was input into IES. So I would change, so I would check the profiles and things like that and make sure that they were doing what I thought they should be doing. And made sure that system efficiencies were correct and things like that. So I think I may have changed the mechanical ventilation slightly when I did this one. I think that was doing something that was a bit strange.
- 75 **IN: So when you changed your mechanical ventilation you were able to achieve compliance?**  
 I10: Yes.
- 80 **IN: Describe (approximately) the variability in results that was observed (in percentage).**  
 I10: Not that specific change no.
- IN: So you can't remember, it just helped your building pass.**  
 I10: Yes.
- 85 **IN: How did these results feedback back into informing the building design process? (or was is separate?)**  
 I10: Well, they didn't really.
- IN: So it was separate?**  
 I10: Yes. It was run to comply to with L2 and it kind of, it's a useful, it's quite useful to confirm some of our other calculations. But in this case, that's what it did, because it did pass.
- 90 **IN: Are you formally accredited to carry out Part L2A compliance calculations?**  
 I10: I haven't got the consultant's-  
 I0\*: You've done the IES Part training.  
 I10: I've done the IES Part training.  
 I0\*: And not for the EPCs
- 95 I10: Yes.
- IN: What route did you follow to submit you work?**  
 I10: It hasn't actually been submitted yet. They will be in the next couple of weeks, I think.
- IN: Did you use any internal methods to assure quality control and the validity of your results?**  
 I10: No.
- 100 **IN: Your building hasn't been submitted so you don't know if it's been passed or not?**  
 I10: Yes, that's correct, yes.
- IN: Did any of your team have any contact or interaction with Building Control?**  
 I10: No.
- 105 **IN: What are the main issues, if any, did you encounter during the simulation process? Please describe these issues.**  
 I10: There were, what we had in this project, it was mostly naturally ventilated and we had plenums going across corridors, so it was cross-vented from classroom over the top of a corridor. And so that meant I ended up with hundreds of rooms and a lot of them were these quite small plenums. And that actually, that was quite a big problem in terms of the software because it seems to, it's just, just because of bugs I think in it, it

110 actually meant that I had to delete a few of them to make it, because otherwise it wouldn't run. It had some problem with geometry or something. And after sending the model to IES a couple of times, they came back and said rebuild these sections. It wasn't properly resolved, just a few of these plenums aren't in the model.

**IN: So it's modelling?**

115 I10: Yes, so there's a few issues with the modelling and then the plenums seemed to work as I'd expect them to, once the ones that were actually there- but how accurate that is, I'm not actually sure.

**IN: Did you have any other problems with the tool?**

I10: Yes, as I said before, changing things, modifying things that you've already built is very, very difficult. There's no easy way of doing that. And I think just the way the windows work is also quite, I think is also quite a laborious process to go through and make sure every window is opening the correct amount and things like that.

**IN: So the schedules for the windows?**

I10: Yes, the schedules for the windows and also how that schedule is assigned to a particular window I think is quite a difficult. I think it's easy to get that wrong.

**IN: So did you have any issues with modelling the building systems?**

125 I10: I think the way it does the heat emitters. It comes up with a, it gives you a little menu which you can use so it can calculate certain efficiencies for you, or you can just put in the efficiencies yourself. And if you use that menu that seems to be set up in quite a strange way. And I did find that quite difficult to use when I tried to use it. Just difficult to get why, where all the correct numbers come from. I think, and I think when I used that, it was when I was doing warm air heating. With chilled beams, there's no way of, there's not a very good way of putting something like chilled beams in.

**IN: Which would you regard as the main priority for consideration in future Part L2A revisions.**

135 I10: I think in many ways, it's getting the software so it got less bugs and things would be very helpful. Because you can get into trouble and have to rebuild models just because of one thing going wrong or something. And then the more technical engineering side of things, I think the engineers generally can work around them by doing the calculations manually and then putting them into the program. So that's less of a problem, but it's definitely a problem if it's used to prove something complies with regulation.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

140 I10: I think it's, I think it's a very. I think the main problem with it is there's no transparency and people can plug numbers into this computer program and then you get something out that says 'yes it passes' or 'no, it doesn't pass'- but you can't see how it's got to that pass kind of thing. So I think it is, it's overly complicated and not transparent enough. But having said that, the actual idea is incredibly complicated and I can't see any really good ways of doing it. I would quite like to see a spreadsheet or something.

I0\*: It's what we do.

I10: Exactly, it's what we do ourselves. That is limited in what it can do.



### Interview 11 Transcript

**IN:** Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?

I11: Ok, I was going to talk about (name) music school, which is a, it's actually just the music department for a school, for an existing school in (town name) in Essex. And its, so it's a new build building, but it's adjoining an existing building in the dining hall area. So most of it, more than 90% of the building, is all new build Part L2 and then a small amount of it is just a refurbishment of the existing building that's adjoined to it, which is being evaluated by variation Part L1. It's about a 1000 square meters, 2 million pounds.

**IN:** Can you briefly describe the systems that were used?

I11: It's got, programs for evaluating it?

**IN:** No, the HVAC systems, the HVAC.

I11: Oh right, it's no air conditioning but it's got lots of mechanical ventilation because of the music department. So most of the rooms are individually ventilated so they're kept acoustically separate from each other. So there's a variety of local ventilation systems and centralised ventilation for the performance hall as part of it as well. And the heating system, it's all centralised boiler with a radiator heating and underfloor heating. And the lighting is a mixture of mainly fluorescent lighting throughout except for, well at the time it was modelled, the performance hall had specialist house lighting which was tungsten lighting in there.

**IN:** What were the main design criteria that were considered in this project?

I11: In terms environmental criteria, or?

**IN:** General and specifically any sustainability targets.

I11: Oh, right. There weren't any actually any sustainability targets for the project itself.

**IN:** Apart from Part L?

I11: Apart from Part L, yes. So the focus mainly was on the I suppose the acoustics side because it's a music department, so it's mainly about achieving separation between the spaces. So the intent was to try and relax those requirements where possible and try and use as much, and use natural ventilation where possible. But often it's complex with the need to keep the spaces separate and not have large openings between them.

**IN:** Which software did you use for this exercise?

I11: It was IES

**IN:** Version?

I11: 5.8.1. Initially and then it changed to 5.8.2, which was one of the sources of problems.

**IN:** Why was this tool chosen? (Were there any influencing factors-financial...etc?)

I11: Because that's the, it's the tool we have available and we don't tend to use the SBEM.

**IN:** How would you rate your proficiency and experience in using this tool (prior experience, training....etc)

I11: Well actually, I didn't do the modelling. (my colleague) did the modelling part but I was overseeing him basically.

**IN:** So you were supervising?

I11: Yes.

**IN:** So are you able to use IES?

I11: Yes.

**IN:** Ok, so have you received any formal training?

I11: Yes.

**IN:** Would you have preferred to use another tool?

I0\*: Our spreadsheet.

I11: I think no, not necessarily.

**IN:** Could you briefly describe the process that was involved with achieving Part L2 compliance for your project?

I11: So, the, in terms of the fabric we set out the U-Values we advised the architects to set the U-Values. They set them at normally 30% below sort of, the old Part L sort of standard. So we advised them to do that. And then obviously looking at the air-tightness, achieving the necessary air-tightness as well.

**IN:** So what were the steps? How did you source the information for your model?

I11: The actual how we go about the model? That was based on just some of the architects' backgrounds and it was, so that was used to build the model and then specifications, the architects' specifications for the fabric. Then on the services side we've been based on our design information for the heating and ventilation and the lighting. And we would've, on our side we would've provided information on light watts/m<sup>2</sup> of lighting.

**IN:** So that was entered into your model?

- 55 I11: That was all fed into it.  
 IN: So you mentioned you supervised this project so, how were the different roles and responsibilities for each of the group members structured?  
 I11: So (my colleague) was undertaking the actual carrying out of the model and the he was feeding that back into the, who was providing the information back to us and how it was going and if we were achieving it.
- 60 IN: And you oversaw the process, then?  
 I11: Yes.  
 IN: At which stage of the design process was the Part L compliance simulation exercise undertaken?  
 I11: It started, more, it was coming up towards tender time. So it started about a month before tender.  
 IN: Stage F?
- 65 I11: Yes.  
 IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)  
 I11: No.  
 IN: So no technical help from IES or anything?
- 70 I11: Oh, from IES. There was some, yes, there was some discussions with them actually, yes.  
 IN: Throughout the modelling process?  
 I11: Yes.  
 IN: In your opinion, was this the appropriate time to undertake the simulation exercise?  
 I11: It could've, it would've helped if it was a bit earlier. But I think if it was any earlier we wouldn't have had the sufficient information to be fed in. So I think it did work. It worked reasonably well. We were able to pick up, there was time to pick things up and incorporate into the scheme, into the tender scheme, so.
- 75 I0\*: Did you use the spreadsheet really early on?  
 I11: No, no.  
 IN: How much time (in man hours) was approximately spent on the simulation exercise in total?
- 80 I11: It was about 100 hours.  
 IN: How did this vary from the time you initially planned to spend?  
 I11: It was more than we expected. But we had, it was within the amount we'd advised the client that it would take.  
 IN: So how much longer did it take?
- 85 I11: I think it probably took about 30, 40 hours longer. About a week longer than we would have hoped.  
 IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?  
 I11: Yes. Initially with 5.8.1 and then we, the versions changed and when we remodelled it, apparently the same parameters, it didn't pass the second time the versions changed.
- 90 IN: If not, what kind of measures did you use to achieve compliance? (Design changes or input parameters)  
 I11: So that involved the discussions with the IES technical to try and ascertain what the differences were.  
 IN: And what kind of recommendations did they make?  
 I11: Well, their advice was that it was the profiles had changed in the new version.  
 IN: So did you then go on to change the profiles?
- 95 I11: Yes, there was some adjustments to the profiles made.  
 IN: Can you give a description of the changes?  
 I11: Very broadly, it was to do with the length of time I think that that they were allowing for each day for like the standard kind of school model. My understanding is that those sort of allowances changed between the two versions.
- 100 IN: So you changed the profiles?  
 I11: So yes, we had to review the profiles.  
 IN: And everything else remained the same.  
 I11: Yes. There weren't any no.  
 IN: Which Input parameters did you observe as having the most affect on your results? Describe (approximately) the variability in results that was observed (in percentage).
- 105 I11: As much as, well it changed it enough to pass.  
 IN: And that variability would've been about how much in percentage?  
 I11: It was quite significant because there other element we did change was the lighting because that was a problem. We had found that it wasn't passing, it was in this scenario, the lighting was too high.

- 110 **IN:** So you changed profiles and lighting?  
 I11: Yes. And we actually changed the lighting, we put that back into the design after we changed it. In doing that there was a significant jump in the total carbon we were getting.  
**IN:** So can you remember how much it was, approximately?  
 I11: It was about 25%.
- 115 **IN:** How did these results feedback back into informing the building design process? (or was is separate?)  
 I11: I think it was mainly just the lighting.  
**IN: So the lighting change impacted the design?**  
 I11: Yes.  
**IN: Are you formally accredited to carry out Part L2A compliance calculations?**
- 120 **I0\*:** You did the Part training, didn't you? So you've done that.  
 I11: Yes.  
**I0\*:** But I mean you're not accredited for EPCs?  
 I11: No  
**IN: What route did you follow to submit your work?**
- 125 **I11:** Using the summary sheet from the IES national calculations.  
**IN: BRUKL output?**  
**I11:** BRUKL, yes.  
**IN: I mean were you the person named on it?**  
**I11:** No I wasn't
- 130 **IN: So somebody else?**  
**I11:** Yes  
**IN: An accredited individual?**  
**I0\*:** It was (my colleague)?  
**I11:** Yes.
- 135 **IN: Did you use any internal methods to assure quality control and the validity of your results?**  
**Please describe these methods**  
**I11:** Yes, we. Well we did a, essentially a reality check on the, on what was coming out. And there were some concerns that it wasn't quite what we expected, but it was passing.  
**IN: And that was based on your own experience or known benchmarks?**
- 140 **I11:** Yes, our own experience.  
**IN: Did your building pass with regard to the requirements of building control?**  
**I11:** Yes.  
**IN: Did any of your team have any contact or interaction with Building Control? Please describe this interaction (how, when, method, impact)**
- 145 **I11:** Only initially to sort of set out what we, to make sure what, to check what they were expecting and then we submitted the summary sheet.  
**IN: And how did this contact impact the process?**  
**I11:** There wasn't much, no, it was really only to check what we needed to, what they were expecting initially, I think and the-
- 150 **I0\*:** So it was just before you submitted?  
**I11:** Yes, yes.  
**IN: So it didn't influence the process?**  
**I11:** No, no.  
**IN: What are the main issues, if any, did you encounter during the simulation process? Please describe these issues.**
- 155 **I11:** Yes.  
**IN: You mentioned the variability you got between versions, so if you can elaborate on that.**  
**I11:** So that was, well initially we had modelled and I think actually, the lighting changed-no, we had a model pass in 5.8.1 and very shortly afterwards, the versions changed. And then when we came to redo the, to get the summery sheet out, the values changed basically. It went to, it stopped passing.
- 160 **IN: Did you have any other issues with regard to the tool or the methodology?**  
**I11:** Only the, in some ways we found it hard to, where there were problems, it was quite hard to understand. It was a bit of a black box in the sense that we couldn't see what was going on. Certainly with the results in the end we couldn't tally the summary, the totals that they gave for carbon. We couldn't work out how they took

- 165 the value from there to the carbon per square meter figure that they actually report on the summary sheet. And it wasn't clear where that was coming from. No.
- IN: With regard to, you mentioned that you used natural ventilation, were you able to model the system to accurately reflect what was going on?**
- I11: Yes. We allowed for openings of the, opening profiles for the windows.
- 170 **IN: Which would you regard as the main priority for consideration in future Part L2A revisions. How would you recommend that these issues be dealt with?**
- I11: The actual L2 itself.
- IN: Yes. With regard to the methodology or the tool.**
- I11: I don't know too much about the methodology that's used. I've never seen the actual national calculation methodology or whatever. So I don't know actually how-
- 175 I0\*: Transparency?
- I11: Transparency, yes. I think that's probably the answer.
- IN: So you would prefer more transparency in the upcoming revision?**
- I11: Yes.
- 180 **IN: And with regard to the tool?**
- I11: Similarly that might be, that might be the case as well. It's hard to say what is it actually going on with the tool, what's going into the methodology.
- I0\*: Well, I don't, IES don't publish the theory in full.
- IN: No, they don't**
- 185 **IN: In summary, how would you assess the overall procedure and how do you see it being improved?**
- I11: I think that it, I think that yes, it could be made more transparent and clearer to understand. See what's actually, yes, going on with each calculation.
- I0\*: Do you think that it's too flexible, could it be more flexible?
- I11: In some ways more flexibility actually because it's difficult to model complex buildings. I think that's the-
- 190 I0\*: Mixed use must be a particular horror.
- I11: In some aspects you don't get certain control strategies, so it's very difficult to model. I think things like occupancy control for ventilation and lighting. It's quite hard to actually, although you are achieving, relative to how the building would normally be used, you'll achieve your energy savings. But I think in terms of the way it's modelled my understanding is that you don't, that's not picked up very clearly. Although, you can do
- 195 it in profiles, but that's very hard to, to that level of detail. I think it's probably, yes, it could be more sophisticated in that sense, but then it might be more, too complicated in that way.

## Interview 12 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?**

I12: East of England, sports centre, reason for choice; complex HVAC systems and several lighting zones difficult to model in terms of any current software.

5 **IN: Can you give me a brief description of the kinds of systems you used inside?**

I12: The ones that we used inside, or the ones that are inside?

**IN: The ones that were used inside.**

I12: It's a sports centre with some places almost 90% glazing. It's also got an Olympic sized swimming pool. It's got several conditioning suites, well and it's also on 8 split levels. So there's an issue there with  
10 overheating due to the glass and atria, also we've got a big thermal hook from thermal sink from the sport centre itself. Massive heat load due to occupation as well. Also you've got the problem of glazing indoors and different functions on each level; from offices through to restaurant areas, through changing rooms...etc.

**IN: So what HVAC systems were used in the building?**

I12: About 6 or 7 of them. Depending on what you're supplying, remember that you are using a swimming  
15 pool, the main problem with that is with extraction. It was using a twin boiler system underneath for the mass of the heat load. Because the rest of the building was slightly detached from that, it was then using a different system through air handling units which was a variable air system fed by, into 2 separate boilers. Alongside that it had multi-split because it had a server room as well for monitoring so they had 3-4 multi-splits on the second floor partition on the roof which supplied the server room. Also the reception area was supplied by a  
20 multi-split system as well, independent of that. And the office block, the office centre was served by multi-splits as well.

**IN: What were the main design criteria that were considered in this project?**

I12: In terms of?

**IN: Sustainability.**

25 I12: I'm not sure that there were any specific targets at all.

**IN: It had to just pass Part L?**

I12: Part L and I don't even think, there were, yes there was some grey water recycling as well. But I don't think there targets set on. The idea was do as much as possible. So there was no specific sustainability, there was no BREEAM done in it for end use or a bespoke BREEAM. There was no green print or something like  
30 that done.

**IN: Which software did you use for this exercise?**

I12: Well, in hindsight it would have been a very good one. We were requested by the client to use iSBEM.

**IN: Which version?**

I12: I think it 2.0.c

35 **IN: Why was this tool chosen? (Were there any influencing factors-financial...etc?)**

I12: Because the client wanted it done in iSBEM. It was client driven.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training....etc)**

I12: Expert. I hope so by now.

**IN: I gather that you've received formal training?**

40 I12: I am a competent person.

**IN: Would you have preferred to use another tool?**

I12: I don't think for the purposes of what it was doing, that dynamic simulation tool would have given a better answer. Nor would Hevacomp, or the version then which was a sizing tool for HVAC systems rather than dynamic simulation. However, it might have been better if Carbon Checker or a visual interface had been  
45 available at the time, but it wasn't. The only ones there were, were not as proficient as the ones we have now. For that one, the only problem is we were supplied with drawing, they didn't have CAD files as well. So that was why it was limited by the client not wanting the production of CAD files from the drawings. Then there was cost implication, but it would have been quicker really.

**IN: Other than that you considered that iSBEM was (suitable)?**

50 I12: For the purposes of a compliance check, yes.

**IN: Could you briefly describe the process that was involved with achieving Part L2Acompliance for your project?**

I12: Information was sourced from the design team, M & E engineers. They gave us a full schedule of what the construction types were. Full schedule of the HVAC systems. We had a meeting with the design team and a

- 55 re-meeting with the design team to discuss the, initially discuss what activities were being supplied by certain systems, what variants had gone on with the design, the variants for build or specification and they came back to that. We entered some of the data, went through the process and said, there are certain question marks, here, here and here, back to the design team and asked the question. And that firmed up their specification for the sub-contractors as well.
- 60 **IN: So the information was then entered into ISBEM?**  
 I12: Yes, but we'd come back with some information to enter, run a compliance check or a pre-check and then ask them some other questions as well.  
**IN: So it was an iterative process.**  
 I12: It always is, especially on a complex building.
- 65 **IN: How were the different roles and responsibilities for each of the group members structured?**  
 I12: In terms of information?  
**IN: In terms of carrying out the Part L2A compliance.**  
 I12: The Part L2 compliance, was driven by, the person responsible for that, we were sub-contractors of the M&E engineers. They provide the information and they were part of a design team that met regularly.
- 70 **IN: And you did the simulation yourself?**  
 I12: This one? I Q&A'd this one.  
**IN: So you supervised an engineer?**  
 I12: My colleague was doing it.  
**IN: At which stage of the design process was the Part L compliance simulation exercise undertaken?**
- 75 I12: In the design stage. If you want it in terms of RIBA stages, it was Part B.  
**IN: Stage B. So it was pretty early on then?**  
 I12: Yes, because the whole point is with a building that complex, if you don't do it then, you'll never make compliance.  
**IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**
- 80 I12: Not really.  
**IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**  
 I12: Yes, it's pointless doing it at the end. You cannot change things not in a complex building. You might away with it on shed which you can actually change the insulation levels on the outside to make compliance or you can change the HVAC system, but when you've got a complex interactive building, you've got to do it that early.
- 85 **IN: So you prefer for it to be as early as possible, provided the information is there?**  
 I12: Yes. If the information's not there it means that they're not ready to design it or build it, the design team hasn't done its job yet. When they've got a design, which is a focal design with the design a specification in terms of the construction elements and the HVAC systems, that is the time to do it.
- 90 **IN: So as early as possible then?**  
 I12: Yes.  
**IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**  
 I12: No, but it was something like a week. That's very rough.
- 95 **IN: How did this vary from the time you initially planned to spend?**  
 I12: It ran over by 25%, I know that.  
**IN: So it was a little more than you expected?**  
 I12: Yes. But it was one of our most complex jobs and one of the first we did as well.  
**IN: So this was pretty early on then?**
- 100 I12: Yes.  
**IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**  
 I12: Yes, it actually complied the first time surprisingly enough. Only from the iteration of getting the information in. The real problem was getting the detailed information in the right form to input, especially the HVAC stuff.
- 105 **IN: Beyond that it was fine with regard to compliance?**  
 I12: It works on series of defaults as well. So that's where the iterative process came in because it would default to something and obviously it wouldn't comply then. So you'd have to collect information to give you information rather than the defaults. So defaults are the worst case scenario.

- 110 **IN: If not, what kind of measures did you use to achieve compliance? (Design changes or input parameters)**  
**Did this involve changing or altering the input parameters? Which input parameters did you alter?**  
**Which Input parameters did you observe as having the most affect on your results?**  
 I12: On this job or on other jobs?  
**IN: Specifically on this one, then generally**
- 115 I12: This one was the heating load, because you've got a swimming pool.  
**IN: So the heating load played a vital part?**  
 I12: Because if you've got something that's got all that glass and it's got a big heating load, the lighting tapers down. If you've got an office scenario, a warehouse scenario, the lighting is far larger. People underestimate, but it can be 40-50% of the energy load.
- 120 **IN: That much?**  
 I12: Yes. And retrospectively, if it's a badly designed building and you're doing an EPC rather than compliance or an EPC for a major refurbishment, the lighting load can be huge.  
**IN: So for this project it was heating.**  
 I12: Heating, because once you've got a big thermal sink like a pool, its heating and cooling.
- 125 **IN: Describe (approximately) the variability in results that was observed (in percentage).**  
 I12: It wasn't that sensitive. Because you had a big thermal mass there. It was much bigger than anything else. The heating you need for Legionella's and things like that, you are limited by other parameters and a sensitivity analysis isn't really going to help. The only thing that would reduce the energy loads is by putting some type of renewable system in, tying that to a heat pump. But this was a site in a middle of a town, where a heat pump for that would have to be in either a lake or underground in a large area. That wasn't available.
- 130 **IN: So in general with regard to other building types and other parameters, can you give me an idea of the variability you get when you have other building types?**  
 I12: Compliance or EPC?  
**IN: Let's start with compliance.**
- 135 I12: Compliance is far easier, because you have the as-new built specification and drawings. So really as long as you've got all the information and you're asking questions and the design team can give you that information, the variability is very small.  
**IN: That's with regard to all building types?**  
 I12: Yes. As long as you know what's in there. If you want to change what's in there and do a different design, that's far different. If you want to put in a different HVAC system or a different HVAC strategy and do a different strategy, of course the results are going to change. I mean, If you've got the same building and you do a naturally ventilated version and a mechanically ventilated version and an air-con version, you'll get a variation of about 40%.
- 140 **IN: Between the different ventilation system types?**  
 I12: Yes. In the same building.  
**IN: That's considerable.**  
 I12: That's obvious. So you can see what I mean. Talking about the HVAC strategies at design stage, now because compliance, the compliance check, checks like for like, i.e. compare an air-conditioned building with an air-conditioned notional building with an improvement factor on it, is different from an EPC check. So you're going to have different- for natural ventilation, mechanical ventilation and air-con buildings you're going to have different energy uses, and with an improvement factor on the notional building to give you a compliant building. So they each have a different baseline, that's what I'm saying. You're comparing like for like, there is no common baseline. So if you're going to design stage and looking at different HVAC strategies, of course you're going to get a different answer. And you're going to get a different answer for different compliant buildings. So you might get different buildings with three different strategies all compliant, but ones going to use a lot more energy than the other.
- 155 Now there is an issue there when you go to an EPC, on side that they will be given different ratings as a result. And always you will find that a natural vent will be around a B, mechanical vent will be around a C, but an air conditioning will get a D. And the issue in the marketplace is why are we differentiating that. Well were generating that on energy usage not on how efficient you can make that building compared to a like for like building. Because there's some scenarios such as the London heat island you need air-conditioning, so it's unfair to penalise them.
- 160 **IN: By passing and failing regulation?**  
 I12: Yes, but sometimes though, if you look at the marketplace, they'd all be air-conned. But there are some

165 buildings where we don't need air-conditioning as being used. So why should the person renting that and  
 paying for that, despite the location where there's a naturally ventilated building just round the corner being  
 used. So the marketplace's transparent. And that's the reason for having the difference in terms of the baseline  
 number.

**IN: You also mentioned lighting can be a big factor. What building types did you observe this to happen  
 170 in?**

I12: In the majority of building types, apart from when they've got a very hairy air conditioning load or  
 heating load. Yes, you take a hospital for example, that's got a massive heating load and an air-con load so  
 you're not going to notice that. It's inherently heating efficient. But if you go to a warehouse for example, the  
 heating load is very low, at lower stages for frost protection as well, the lighting design will have a bigger  
 175 effect. That's also true for any requirement for higher lux levels. That could anything from (cad) to design of an  
 office for example, to inspection work in an industrial unit. Unless you put in the right lux loads in there and  
 do a proper lighting design, what will happen is inherently the lighting load is going to be heavy. Simulation  
 tools and compliance tools allow you to have that heavy load because they deliberately designed it in.

**IN: What's the percentage contribution that you generally observe with lighting?**

180 I12: Depends on what the building type is, but it can be anywhere between 20 and 50%

**IN: That's a huge contribution.**

I12: Yes. There are not that many, my organisation used to do all the benchmarking. If you look on the Carbon  
 Trust website-have you been on there?- The benchmarking guides, we wrote them. And we've done surveys,  
 we've got a database downstairs, of building stock. The database is of domestic and commercial building  
 185 stocks which tell you what the lighting uses is. From experience, it can be big, it can be small. It depends  
 certainly on the building and what's been done with it. How much, even office blocks, even air-con, how much  
 natural light comes in. How do you design to improve that, have you put skylights in, have you done that. So,  
 the (island) you going to have to have more lighting and more significant lighting with control. Even control  
 systems, because you have the 6 meter rule- so you're going to have to come in, you're going to have to out  
 zoning controls in. So really, it's very bespoke.

**IN: So to be very approximate here, by changing or introducing energy efficient measures in terms of  
 lighting, what variability would you expect in terms of compliance. What's the decrease in carbon  
 emissions you would get by that?**

I12: It really does depend what the building is. But you're going to have to use either a pre-designed system or  
 195 T5s and put some kind of control in. And that means you're going to have to have pre-lighting zones with  
 dimming and photo-controls as well and in manual control offsets.

**IN: And that total reduction in carbon would be?**

I12: Up to 50%

**IN: That is a lot.**

200 I12: It really does depend on the type of building and what it's for. In a retrofit in can be as large as that. I  
 mean in pre-design designed building, where most of the specs are up to T8s, it might not be that large.

**IN: How did these results feedback back into informing the building design process? (or was is separate?)**

I12: It was a reasonable design, there was a few things that had to be changed. Some of the ( ) design, some of  
 the lighting design had to be changed as well because, I don't know why, but some of the places they were  
 205 putting display lighting in and it wasn't necessary. It was far heavier than what it needed to be. The idea was  
 having bright light everywhere people needed to be walking in the building. I mean there was no need. So for  
 example in the reception there was an increase in day lighting from some of the roof design at the front, a  
 reduction in the lighting that was in there. There was no need to put halogens everywhere.

**IN: So you mentioned that you were accredited to carry out compliance calculations?**

210 I12: Yes.

**IN: So you're a competent person?**

I12: Yes.

**IN: So you were the person named on the document for building control?**

215 I12: Yes. The person who did the work, by the time it went through to the hand over stage, he was competent  
 as well. There are 4 of us here who are on the old competence scheme which doesn't exist anymore. 3 of them  
 in the design office and now we QA each other's work. I had the competency ticket first, so while they were  
 doing it, I was checking their work. We were designing the QA system alongside of it and making sure that we  
 actually captured everything.

**IN: Did you use any internal methods to assure quality control and the validity of your results? Please**



220 **describe these methods.**

I12: What all projects?

**IN: Generally**

I12: Generally, we're ISO9001, ISO14001 and UCAS accredited. So that means full control systems for everything. Full control documentation, quotes, everything else, all of our jobs are captured on a shared drive with restricted access. They're all logged in and out, there's a complete system for monitoring from cradle to the grave as well. So we've got 4 management systems on site. Individually for these jobs, if you want more detail, the collection of information is basically done- normally there's a storyboard, there's 2 or 3 checklists to make sure that we collect the right information. We have a timeline checklist to make sure. We have alongside that, there are formal complaint logs, if the client complains. There are also logs for any project, not discrepancies really, if the project aims and objectives change slightly so we capture that. So it's almost like a print.

**IN: And you check the results you get out?**

I12: Yes, I mean basically it's done like, the scenario is basically that we'll run, check the data input, collect that on a spreadsheet, we check that against the spec. For QAing, we'll do certain areas, asking questions, run through data with somebody else, the data is then input. We'll then download the objects database from ISBEM for example, check that for a certain number of selected zones against the input spreadsheet to make sure that they are identical, then we'll run the program.

**IN: That's quite an extensive QA procedure.**

I12: That's proper QAing.

240 **IN: Did your building pass with regard to the requirements of building control**

I12: By the end of it, yes. Because the compliance checking here was part of the design stage, and therefore the lessons learnt from putting the data in, the integration was at the early stages. There were no problems about retro-engineering at all, which on other projects is normally the problem. They leave it too late, it's not part of the integral design stage and then you have to retrofit to the building, which is happening quite often at the moment. Because people haven't taken the compliance checking seriously, till the EPCs came along.

**IN: So that was quite recent, so people are scrambling to.**

I12: And they're wondering why their buildings are failing, and they're blaming the software for it. The software is not the issue, the issue is that they haven't taken it on board in terms of the design process. So therefore, they are liable. Some people sweat quite a lot.

250 **IN: They have been, they have been. Did any of your team have any contact or interaction with Building Control?**

I12: On some of these jobs, yes.

**IN: Please describe this interaction (how, when, method, impact)**

I12: Not very much really. They're job, I mean because we're confident, they're job is to take care of work. They either take it as read, because we are competent people, or they come back to us, also we get some of them want to ask about other peoples' submissions. Because the submission doesn't have to be made by a competent person, it can be made by somebody else, however it has to be checked by somebody else. And they either come back and say 'what's wrong with this and what's right about this?'. Sometimes we do some retrospective checking as well. Also quite a few of the control officers are actually coming on our training course

**IN: So their feedback with regard to this project didn't really impact the project?**

I12: And also at a strategic level we have links with the association for building control officers and their head people and we give them information to pass down for informative notices to their members as well. What the compliance checking means, what you need to do. So we try to inform them. From the strategic view we also inform the industry of what is going on. That's what BRE is about, the consultancy stuff is just to keep our hand in, look at the marketplace and stuff. We're into strategically advising the bodies on all issues of sustainability and then producing the training and the examination backup as well.

**IN: So you have quite a strong relationship with building control?**

I12: Yes. And the CLG because we're trusted, we're not a commercial company, we're a charity with 3 companies underneath making profit, but that only feeds into the charity which then supports these 7 research groups in the UK. It supports 7 chairs as well, so we haven't got an axe to grind basically.

**IN: What are the main issues, if any, did you encounter during the simulation process? Which would you regard as the main priority for consideration in future Part L2A revisions.**

I12: In general people seem to forget that ISBEM is a compliance tool and not a design tool. It was never design

275 and it never should be. Second is when and where you use the graphical interfaces. Now, if you have a building with lots of repeating structures, it's much easier to input the data directly into the interface, however if you have bespoke, or different floor layouts all the time, you really want to use a CAD file to do it. Now that's ok to get to complicated buildings with – we're having a discussion internally at the moment about night-vent scenarios and water cooled, underground water cooled. The advice is at the moment, those with  
 280 glass atria should be done with dynamic simulation. Some people downstairs are not convinced that it's any better than SBEM, so there is a discussion going on and they think it's better in version 3.2.b, I think they are. This is the Ireland version tagged onto the end of the Eire version. It will take on more. So it will be better to model these ventilation strategies. Really it would be nice if the compliance tool was broken away from the design tool. My personal feeling is that Tas, IES and even Hevacomp simulations are nice tools, but they're not  
 285 really set out to do compliance checking. And it's a really long winded process to actually get a compliance check out of it.

**IN: You mentioned that you used several HVAC systems within this building, now since ISBEM is not a design tool, did you need to use another tool to size?**

I12: We weren't doing the sizing, someone else did. We only did the compliance checking.

290 **IN: So you had the information from the people who did the sizing?**

I12: Really, yes.

**IN: And you were able to accurately these systems within SBEM?**

I12: Yes, that's not a problem for compliance checking, not for the effects of the design. They're 2 different things and problem is when people get confused with regard to the two. Really you want to say, design it for  
 295 what it's used for, minimise the energy and then run the compliance check. And there should be 2 separate models and the problem as I said, Hevacomp is not too bad because it's got a separate compliance model, you can put it out. So in your mind as a designer or someone doing compliance checking, that's a separate bit of work and actually re-writes-to do the compliance checking-some of the data within the model. It sets it to other defaults and other activities and compares that to the notional building, that's the problem with  
 300 simulation tools. You have to manually reset some of the data before you do the compliance checks. Your simulation model for simulation and your simulation model for compliance will be slightly different, and that's where you get errors. Because it's not a formalised procedure, you're not taking a data file, shoving it into another module and then pulling out the information. You're using the same data file, having internally changed the data. You as a compliance checker have to make sure that you've done it all correctly, then you  
 305 run it again to run the compliance check, which is far harder. So my personal opinion is that you either keep it separate or have an additional module on it. However for the amount of buildings that are going to be done by dynamic simulation is it really worth the effort of producing the separate model to actually do that? Because the majority of these seem to be done by SBEM, until you get to a really complicated building. So my personal opinion is that however in the marketplace is there commercial drive to produce that? Probably not. And the  
 310 biggest sizing tool for M&E which is Hevacomp has got a separate module anyway. So you've probably got 90% of the marketplace covered.

**IN: How would you recommend that these issues be dealt with?**

I12: That's difficult because its commercial return here. They've been certified, or some of it has been certified by CLG and Faber Maunsell, so it can do that. The problem then is quality control of the people producing it  
 315 and I have no idea how their organisations work and that's where the errors is. Unless you check it properly, especially with something like Tas where you can have 3 or 4 in rows the market because its flexible in what you change and what you don't change, unless someone's checking that to make sure that inherently the process has captured that, the way they've produced that building, you can't. But that's up to, you either make the module add-on more formalised or you've got to believe the quality control of the people who put the  
 320 numbers in. You have no control over that.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

I12: There's nothing wrong with the process, only the enforcement.

**IN: The enforcement?**

I12: I think now with the EPCs the enforcement has got far better. Building control officers in general are  
 325 overworked and under resourced. So Part L, to be quite candid about it, it's been nice to have, until recently. Now with EPCs in place where there has to be handed over at the handover point as well and that is policed by trading standards people. And if it's not what's on can is what they're producing, it's now a case of fraud. That puts a different legal spin on it. It's not in the control of the building officer, to take it along with safety, fire, structural integrity ...etc. it's now a bigger commercial issue. That will drive Part L compliance to be

330 better because it's now a commercial issue, and now the running costs or the cost of that asset are transparent to the client, but also to the prospective buyer or leasee. So there's a commercial decision to be made and if the information between the two has to go through the lawyers, that then drives it down.

### Interview 13 Transcript

**IN:** Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?

I13: It's a school extension of about 5000m<sup>2</sup> in Milton Keynes.

**IN:** What were the main design criteria that were considered in this project?

5 I13: It was the Milton Keynes planning criteria D4 which gives a 25% energy reduction on standard practice and a 10% renewable requirement.

**IN:** Plus Part L as well?

I13: You need Part L, yes.

**IN:** Did you have certain sustainability targets?

10 I13: Not other than those, no.

**IN:** Which software did you use for this exercise?

I13: Hevacomp.

**IN:** Design Database?

I13: Yes.

15 **IN:** Why was this tool chosen? (Were there any influencing factors-financial...etc?)

I13: Why did we choose that? Because that is the tool we use in-house. We chose it as a tool because it's a one-stop shop. We can take in through from design inception stage right the way through to CFD. And because it's a one-stop shop, all our training needs are dealt with in one hit and so it's pretty much a reasonable industry standard. Most people have been trained at colleges and universities to use Hevacomp. So the people we bring in are pre-trained.

20 **IN:** How would you rate your proficiency and experience in using this tool (prior experience, training....etc)

I13: My personal proficiency? Well, I'm an EPC assessor so I've been assessed in its use so fairly good.

**IN:** Would you have preferred to use another tool?

I13: No.

25 **IN:** Could you briefly describe the process that was involved with achieving Part L2A compliance for your project?

I13: For the project. Yes, right so we've inputted the information.

**IN:** Where was the information sourced from?

30 I13: Architectural drawings, we then, the way we went about it as far as the Milton Keynes requirement which is 25% reduction on standard practice, we pulled in what we felt would be standard practice, so there was ventilation in there and other things. And we weren't necessarily looking for a pass, an L2 pass at that stage, so we developed up a model that said X was our CO<sub>2</sub> consumption. We then left that as a standard and looked at options for reducing that standard. So we put in natural or passive ventilation systems, looked at increasing boiler efficiencies, whole to generation efficiencies and then we reduced down to become. We looked at lighting control and lighting type and efficiency, there's not too much what you can do with a school. They did have some kitchens, we looked at heat recovery there in the kitchens, and the changing rooms required some ventilation, we looked at what we could get out of the ventilation there. Plugged that in, saw what we got, went through a number of iterations and came up with something that was 25% better than when we started. We then looked to Part L compliance. We had a 10% renewable requirement anyway, and I think we were just inside the Part L compliance before we added the 10%.

**IN:** And then that went to building control?

I13: That went to planning at that stage and passed.

**IN:** How were the different roles and responsibilities for each of the group members structured?

45 I13: Right, I mean the first thing is information gathering from various people and there is an iteration process. On this one we did actually look quite significantly at the glazing to increase the performance of that as much as we could and therefore reduced the overheating issues. We collate that, we fill in any gaps and we provide a report on where we've filled in any gaps where people haven't. We thought about the concept and advised the client at stages with cost issues that are involved in that and how that fits into their scheme and their costing and views on energy efficiency. We bring that in, we tend to provide it to juniors to input the information and then we have a more senior role who then reviews the information on screen just to make sure it's correct and right and then we take it on from there.

**IN:** You mentioned you advise on envelope and MEP as well?

I13: Yes.

**IN:** And you directly deal with the architect?

- 55 I13: Predominantly yes. On that one we were working for the contractor as well. The contractor had an input because he was controlling the purse strings.  
**IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**  
I13: Right at the front end.  
**IN: With regard to the RIBA stages?**
- 60 I13: It would have been probably D.  
**IN: So not very early?**  
I13: Well, D is scheme design, isn't it? So it was early enough. The project went from, it was designed pre-2006 initially. It had been priced and obviously it hadn't got planning at that stage. The contractor had taken it on for a price and then they've had to develop that price into a scheme that worked. So whilst it was at D, it was at front stage for the contractor and it was only, if you like, this lump of work done pre-2006 it got to –you could call it-D.
- 65 **IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**  
I13: No
- 70 **IN: In your opinion, was this the appropriate time to undertake the simulation exercise? At which stage would you have preferred to undertake this and why?**  
I13: On that project, yes. On others, no. Generally we think they should be done pretty much in inception or outline stage. Purely because we need to advise what the purchaser is actually buying and that is particularly relevant with EPCs rather than Part L.
- 75 **IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**  
I13: Probably looking about a week total man hours. About 40 hours.  
**IN: How did this vary from the time you initially planned to spend?**  
I13: Not really, No.
- 80 **IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**  
I13: No. Because we weren't looking to. Because we had this 25% planning requirement on what they considered to be standard practice. Really what we wanted was that to be as high as possible, so we can achieve the 25%. So that initial run, we didn't expect it to and in fact we went through a number of iterations.
- 85 **IN: If not, what kind of measures did you use to achieve compliance? (Design changes or input parameters)**  
I13: Lighting control.  
**IN: So that was a design change rather than changing input parameters?**  
I13: Yes. Boiler efficiencies, domestic services, heating efficiencies.  
**IN: Did this involve changing or altering the input parameters?**  
I13: No
- 90 **IN: Describe (approximately) the variability in results that was observed (in percentage) for these design changes.**  
I13: I'd be guessing. Probably looking 5 to 7 % as a guess overall.  
**IN: How did these results feedback back into informing the building design process? (or was it separate?)**  
I13: Yes. Passive ventilation, windows...etc.
- 95 **IN: Are you formally accredited to carry out Part L2A compliance calculations?**  
I13: Yes. Part L? I'm accredited to carry out EPCs which should be the same thing. I'm a Low Carbon Consultant and an EPC assessor.  
**IN: Did you use any internal methods to assure quality control and the validity of your results? Please describe these methods**
- 100 I13: Yes we use senior people to check the input and check the results.  
**IN: Did your building pass with regard to the requirements of building control**  
I13: Yes.  
**IN: Did any of your team have any contact or interaction with Building Control?**  
I13: Not on that one, no. That was purely planning that one. As a general point on building control, very rarely has interaction with them taken place, apart from they ask for the certification and that's it.
- 105 **IN: With regard to approved inspectors?**  
I13: They're pretty much the same.  
**IN: What are the main issues, if any, did you encounter during the simulation process? Please describe these issues.**

- 110 I13: That particular project went fairly well to be honest. We do have problems with software. We have problems that we think is associated with numbers of rooms where it just grinds to a halt and won't give you an EPC certificate beyond a certain number of rooms. Now whether that's a BRE issue or is though as much and that's given us a couple of problems on some jobs that we're having to break models down and try to make them simpler or try to produce them on typical floor basis rather than on a whole building basis.
- 115 **IN: This is challenging for large commercial projects.**  
 I13: I've got buildings out there with 400 plus rooms on it and I'm having problems getting 150 through at times. But that varies, it varies on the same model almost day to day. I've had buildings where I've managed to get certificates up and then I'll come back to it and it will freeze.
- 120 **IN: Which would you regard as the main priority for consideration in future Part L2A revisions. How would you recommend that these issues be dealt with?**  
 I13: It is to consider rectifying the problem on getting a pass on a naturally ventilated heated building. That's the main thing I think they should concentrate on. They favour air conditioned or ventilated, you can get those to pass, you can introduce ventilation where it really ought not to be introduced and obtain a pass and therefore increase energy consumption if they're used.
- 125 **IN: Any other issues you think they should prioritise?**  
 I13: I think there's a problem with putting in particular systems in that it's fairly inflexible on introducing elements that provide you with an energy benefit and that becomes very difficult to assess. So if you put in free cooling to a fan-coil system for example, or a chilled beam system and there's actually nowhere to input that apart from trying to make an assessment of the seasonal energy efficiency of the chiller which isn't particularly good. So a provision for that which doesn't hang out as a study that goes below the line I think is one big one.
- 130 **IN: In summary, how would you assess the overall procedure and how do you see it being improved?**  
 I13: The entire package? That includes EPCs, everything? I think the procedure is not adequately understood, I think it's open to abuse. I think the standard calculation method was caught between 2 stalls, I think they tried to make it too simplistic so that everybody could use it and therefore there's a lot of items that you would look at and say well that's actually below the line, if it's below the line then you cannot introduce it back into an EPC, but you can argue or report it to building control and you can describe that. But your EPCs still comes out that it could be a fairly poor building. So they need to come up with a joint up method to pick up all those issues up.
- 135

### Interview 14 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?**

I14: It's a large office tower, I think it was about 17 or 19 storeys tall and it had an all glazed façade. In London. The base system was a water-cooled chiller, efficient boilers. In the end we decided that we were going to put in a CHP to reduce the carbon emissions and the CHP was going to be a fuel cell. What else, efficient lighting, all that stuff. So efficient lighting I think we said we'd achieve 12 w/m<sup>2</sup> in lighting. Efficient, well the glazing had a G-Value of 0.35. I don't know which level of detail you want me to go into. Those were the important things. Then the air permeability we put 8.

**IN: What were the main design criteria that were considered in this project?**

I14: We kind of set our own design criteria because we're M&E engineers, so we're also the designers. So it was basically achieving Part L and surpassing Part L by as much as physically possible. And usually our process would be that we put forth the most energy efficient building to our client, and then they'll value engineer in the future and say 'well, we want to get rid of this because it's too expensive'. I'll say 'ok, but now your passing by X percent', but we always build in a margin to allow for that.

**IN: Did you have certain sustainability targets?**

I14: Yes, so the GLA requirement was 20% CO<sub>2</sub> reduction from renewable, which we are getting fuel cells approved for as renewable because it's going to be switched over to hydrogen when that's available. And that's it and just Part L.

**IN: Which software did you use for this exercise?**

I14: I used Tas 9.something. The most recent version.

**IN: Why was this tool chosen? (Were there any influencing factors-financial...etc?)**

I14: Because it was a complex building, Hevacomp couldn't deal with all the different systems and because it was a large office tower with several storeys, Tas is better at copying the floors up, you know in Hevacomp you can't copy the floors up, whereas with Tas you can. So it's time-saving.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training...etc)**

I14: Well, I would say it was as good as anyone. Often when you call the Tas people and ask them for help, they'll give you a mathematical answer, they don't understand the engineering side as well as people like myself and others who actually do the designs.

**IN: So did you receive any formal training?**

I14: Yes.

**IN: Would you have preferred to use another tool?**

No, we just had a presentation from IES the other day and that looked like a good software, but I'm don't (know). So no, I'm happy I used Tas.

**IN: Could you briefly describe the process that was involved with achieving Part L2A compliance for your project?**

I14: One of the things with Tas, I don't know if this was interesting for you, because it was such a large building and had a lot of zones, I almost went over the limit with the number of zones I used. I don't know if you know, but with Tas there's a limit of I think 400 zones per simulation. It failed the first time and I had to go back and like, join two toilets together, because two toilets that were adjacent and I zoned the separately, I don't know why but- and it worked I reduced the number of zones.

Well, I mean I put in all the energy efficiency measures I described before, I just plugged them in. This is for planning application, so the detailed design is not done yet, and that's usually the case when we do these preliminary Part Ls. What I did, as I'm not the lead engineers, is I spoke to the lead engineer for that project and he told me 'we're going to use a water cooled chiller with X efficiency and a boiler with this efficiency' ...etc. and I said 'can I assume that we're going to have energy efficient lighting and can I assume that there's going to be daylight controls ...etc?' and then he said yes. So we had a dialogue.

**IN: So you worked with another engineer, sourced the drawings but you did most of the modelling?**

I14: I did most of the modelling, yes. I can start the geometry without speaking to them, but I can't start inputting all the data until I spoke to them to know what type of building fabric we're going to use. I also met with the architect, but it was to discuss a little bit of that and most BREEAM, so we discussed building fabric as well with the architects.

**IN: How were the different roles and responsibilities for each of the group members structured? So the architect did the drawings, you did the modelling and the other person (in your office) supervised the whole thing?**

- 55 I14: Well, so the way it usually works is that I do everything. This particular project, because it was a big, high profile one was a bit different. But in most circumstances, I just make assumptions and I'll list my assumptions. And I make assumptions that I know will pass, or I'll tweak them to make it pass and I say 'this is what you need to pass'. I this particular case, because the architect was working on it a lot they already knew what kind of glazing they wanted and they knew what kind of solar shading they wanted on the south
- 60 ...etc. The building fabric and the design of the physical building was done by the architect, obviously, and then I got the efficiencies and the mechanical systems I got from another engineer.

**IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**

I14: It was before planning, it was trying to get planning.

**IN: With regard to the RIBA stages?**

- 65 I14: What is that A or B? I'm not sure. It's pre-planning and the reason we had to do it was for the GLA, because the GLA wants their 20% carbon reduction through renewable and we need to show that.

**IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**

I14: No. I mean with M&E, we're an M&E firm, so it was someone from within us.

- 70 **IN: In your opinion, was this the appropriate time to undertake the simulation exercise?**

I14: Yes, I think it's yes, and no. Yes, because it's good to start to have an idea of what you need to pass Part L. No because before planning no one's started the design yet. So, it's kind of like too early.

**IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**

I14: It's a little bit under a week, maybe 3 or 4 days.

- 75 **IN: How did this vary from the time you initially planned to spend?**

I14: It was about right.

**IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**

I14: No, I don't think it did, I think I had to revise the lighting. It was close.

- 80 **IN: If not, what kind of measures did you use to achieve compliance? (Design changes or input parameters)**

I14: I think I included daylighting, and I think that was the thing that made the difference. Usually in office buildings, the lighting is the largest carbon emitter and so a small improvement in that makes a big difference.

**IN: Did this involve changing or altering the input parameters?**

I14: Yes, and running the lighting macro as you probably know.

- 85 **IN: Describe (approximately) the variability in results that was observed (in percentage).**

I14: I don't remember, but it was significant. I can find out if you want. I might have actually made it more efficient, I might have started out with lighting of 15w/m<sup>2</sup> and then reduced it to 12 and on top of that added the daylighting after speaking to the engineer.

**IN: How did these results feedback back into informing the building design process? (or was is separate?)**

- 90 I14: They don't. They will after planning and after we start designing. At the moment they fed into the report that was for the renewable energy, the energy statement.

**IN: So there was no feedback to the architect?**

I14: The architect knows that it passes. Which is important. And the engineer knows that it passes, and what we need to pass it. But it doesn't, I mean we don't go forward to design yet.

- 95 **IN: Are you formally accredited to carry out Part L2A compliance calculations?**

I14: Yes

**IN: Did you use any internal methods to assure quality control and the validity of your results?**

- 100 I14: No. Yes, I know we should, there's only one other engineer. We're a small firm, there used to be 30 of us, now there's about 24 and not everybody's an engineer, some of them are CAD ...etc. There's only one other person who knows how to use Tas and auditing a Tas calculation is time-consuming so when we have problems or questions, we speak to each other or we call Tas but we don't actually check results. I mean we present the results, and for example the other day, my colleague did a Tas calculation for an office/hotel and it showed that the cooling was only 2% of the load. So we looked at that and said 'ok, something's wrong there', so that's kind of an audit, but it's not really of the model, it's of the results.

- 105 And also one of the issues for young engineers without a lot of experiences, which maybe I still am and definitely was when I first started, you don't know what your results should look like. So you get a Kg/m<sup>2</sup> or kWh/m<sup>2</sup> per year or a percentage breakdown and you don't know if that's about right or if you're just way off. In her case, she was way off with her 2% because it should be 20% and we found later that there were things she could do. I mean, I think that's an issue with any type of modelling I think.



- 110 **IN: Did your building pass with regard to the requirements of building control (planning)?**  
 I14: Yes
- IN: Did any of your team have any contact or interaction with Building Control?**  
 I14: Not the planning, no. Well, we spoke to the GLA, because it was a big enough project to be referred to the GLA and they wanted to see the Part L calculation and a whole-energy – are you familiar with that?- so they  
 115 wanted us to take that, transform it into a whole energy and then do a-  
**IN: So they gave you guidance with regard to their requirements?**  
 I14: Yes, but it wasn't specifically on the model.
- IN: What are the main issues, if any, did you encounter during the simulation process? Please describe these issues.**  
 120 I14: Like I said, the number of zones was an issue for that particular one that I could model. Not really any issues-just the limitations on the number of zones that you can do.  
**IN: With regard to Part L?**  
 I14: With this particular one, it worked pretty well, I think.
- IN: Which would you regard as the main priority for consideration in future Part L2A revisions. How would you recommend that these issues be dealt with?**  
 125 I14: There are a lot of things I think are backwards with regard to the way Part L works. The first and the most obvious which everybody says is about cooling. You know you add cooling and you pass. And that's also with domestic hot water, it's the same thing. No trouble if (a boiler) has 40% efficiency, so the more water, domestic hot water you have, the better you are. And before in Tas versions, you had to input your domestic hot water  
 130 load, so that was kind of an easy cheat, if you were close to get a pass.  
 I don't know that modelling it to a notional building is the way to do it, I know in France they do it differently. They have a target kWh/m<sup>2</sup> per year, maybe it's w/m<sup>2</sup> peak – I'll have to check- but they have an obligation per square meter that you're not supposed to pass .  
**IN: A benchmark for each building type?**  
 135 I14: That's right, for building type and depending what type of heating or cooling system you use. But it's because they use, their electricity or a significant percentage is nuclear, so the electricity is actually less 'dirty' as far as carbon than natural gas. Whereas here it's kind of, it really strongly penalises electric heating because of the current source of electricity. Is that the right way to do it? I don't know, I'm not a policy maker, but I would think with the recent problem with Russia and the Ukraine that you don't want to force everybody to  
 140 build all their buildings with natural gas if they don't want to, but that's what Part L is doing.  
**IN: Did you face any problems with understanding any of the requirements of the National Calculation Methodology?**  
 I14: To be honest, no. I just take it as it is and I know it's limitations, we don't use it for design, we don't use it to size our equipment but knowing what data to input where I think is pretty straightforward, to be honest.
- IN: In summary, how would you assess the overall procedure and how do you see it being improved?**  
 145 I14: So do you mean the modelling and the software or the policy?  
**IN: Everything.**  
 I14: Well, the policy is kind of what I said before. The cooling and the hot water and there's a lot of other examples – you take a building that is bad and you make it a little bit better and you're better off than taking a  
 150 building that's good and making it better and things like natural ventilation and stuff like that. Assuming that the national building is cooled- I'm sure I'm just going to repeat what other people have said. I have a lot of policy issues with sustainability in general, but specifically relating to Part L, not so much to be honest. I think in the greater scheme, the Part L calculation is just to show this is our carbon emission and this is our baseline that we need to improve on with the renewable energy systems and I think instead of having the extra  
 155 renewable energy target after that, I think it should just be a target with Part L that you need to reduce. Instead of achieving the TER, you need to achieve the TER+20% and that way a developer chooses the most cost-effective way for him to do it- or her- and you don't end up putting in renewable energy systems that are not cost effective and not efficient .  
**IN: There are regional requirements that state targets for renewable**  
 160 I14: That's what I'm saying. I don't think they should. I think renewables are great, I hope that in the end everything runs on renewable energy. But putting PV panels in the UK just doesn't make sense you can't get a payback. There's a lot more energy put into building the panel, than you'll probably ever get out of it. And people are forcing us, the GLA is forcing us to put PV panels in certain projects because no other solutions really make sense. And even if we're achieving a small percentage, it would make more sense spending that

165 money on improving insulation or buying the most efficient chiller or efficient boiler than it does to do this renewable energy system.

On top of it, I don't know if you want to talk about this, you know ground source heat pumps is approved as renewable, although it runs on electricity and apparently air-source heat pump has just been approved by Europe as a renewable, not in the UK yet. To me that's a perfect example of something that doesn't make  
170 sense, because all you're doing is having a little bit more efficient chiller because it's exchanging it's heat through the air instead through another system, and that's great and people should be encouraged to use that, but it's not renewable. So, to me it doesn't make sense, it should be, it would make a lot more sense to me to say reduce your carbon emissions by a further 20% by any means you want, which achieves the same target rather than have a list of technologies that you have to use. But maybe they have a bigger objective that I'm  
175 not aware of, that they want to be the first in Europe to have a big market for renewable, which is another issue. But I don't think it's the most cost-effective to do it.

### Interview 15 Transcript

**IN: Can you please give a brief description of the project you have selected for discussion (type, components, systems, location)?**

I15: So the project we did was a small outlet, a small building for (company name). And they are wanting accommodation for a couple of offices and a data centre plus various small garage areas for their switchboard gear and stuff like that they were needing. And it's one of these remote buildings that stand alone in the middle of the Yorkshire dales, which is right on where they're running their cables. It's a place where they can then maintain, use as a base and co-ordinate all their cabling and making sure everything is on top of it. And things like that.

It would have been occupied every day, but only by a very few number of people. But it had the option, the capability to host about 12 people in a small conference room and there was a couple of permanent offices based there, so a few work spaces.

**IN: So it was more of a multi-use/office ?**

I15: Yes, I'd say mainly office, but with a lot of IT storage, kind of a specific data kit, and a conference room.

**IN: And what were the building services?**

I15: They had no air conditioning, which was the problem, so it was fully naturally ventilated. And they had just heating.

**IN: What were the main design criteria that were considered in this project?**

I15: As (company name) have a big say in energy, they were really keen to be seen to be green. So they said no air-conditioning and they wanted a big green roof and they wanted it to blend into the big rolling hills. So architecturally, that was how it was driven. Obviously, they wanted that as cheaply as possible, with as little effort as possible. So it was just the building regs that we had to comply to, it was a brand new building, so it was Part L2A.

**IN: Did you have certain sustainability targets such as for renewables?**

No, they didn't have anything at all, unless you count a green roof.

**IN: Which software did you use for this exercise?**

I15: We used IES, I think it was Apache Sim – I think it was on 5.8., something or other. I think we even had an upgrade in between, 5.8.2, probably.

**IN: Why was this tool chosen? (Were there any influencing factors-financial...etc?)**

I15: We use it as our software of choice. It's very easy to get training in it, they're very well established, people have heard of it and the experienced engineers and modellers used it. One of our chaps was part of the main-when it was first being rolled out- he was involved in that, so we've taken it on as the main tool to use. And because they know it, they teach all the new people, so that's how it kind of passes down. But also, it's become really the main, from our point of view, the most recognised software for getting accreditation for LCC, signing off the building regs and signing off EPC things that come through.

**IN: How would you rate your proficiency and experience in using this tool (prior experience, training....etc)**

I15: I have 2 years experience, I have full accreditation for LCC simulation, formal training and formal exams which we had to go through and just quite a few Part L2 sign-offs supervising people to do and just doing them myself.

**IN: Would you have preferred to use another tool?**

I15: It's hard to say. I think with the introduction of EPCs, we've started to state the view that using the full thermal dynamic simulation on a relatively simple building is a little bit overkill. So because the EPC software has been introduced using the SBEM as its calculation method, we would be in a position where if we signed off a building for Part L2A and then they got a new contractor to fit it out or to just do a check-up on the model we've done, then we're more likely to do an EPC using SBEM and they're going to get very different results. So, to kind of make sure there's continuity between what we're telling them they've got and if they get checked up, if they need to get an EPC because they have to get one every time they sell it, and after 10 years it runs out and they have to get a new one and release it, it just makes sense that for simple buildings up to Level 4 we're using SBEM. But we can do that with IES. Other than that, I think we're pretty happy with using IES.

**IN: Because SBEM is time-consuming?**

I15: I think SBEM can in some ways can be quicker, but you've got less flexibility. Say if it is at all complicated, then yes you've got to think about SBEM quite a lot, while with IES you can just run through it. But it's supposed to be for simplified building energy method, so it is quite simple, but we'd stick to IES purely because that's what we've known. I wouldn't really know what the others were like, because I don't have that experience.

55 **IN: Could you briefly describe the process that was involved with achieving Part L2A compliance for your project?**

I15: Our architects did the drawing-in house- it's good when you can do that. We don't always do that, but in this case, it was our architects, so we could get CAD drawings straight from them which we can import into IES 2D, so we can use the DWG, DWF as it converts to create a file template and quickly draw up a model, room by room. Once that's done, apply all the systems and basically go through the process of making sure you've got the right templates and the right building type, the right location, the right weather files ...etc.

**IN: And where would you get the information about the building services?**

I15: Essentially, our in-house M&E team will usually be involved with the design, so if they weren't doing the modelling themselves, we've got a checklist if you like of information- it's a data request form. So we've got certain questions on there that say 'what's the air conditioning end-unit? Has it got radiators or in-floor heating? What's the boiler type, what's the efficiency of the boilers? What's the efficiency of the cooling system ...etc' and that is the responsibility of the M&E engineers to fill out and give to the modeller.

**IN: And that's the system employed here?**

I15: Yes, if it's not, it get really messy, trying to work out what's and assumption and what isn't. So everything is done, the geometry is done, all the services are done, all the templates are done, based on the room definitions that architects provide. And then we run the simulation, and then it would fail, and then ideally – and this is why this was an interesting one, because I only got involved after it failed in this particular one because they wanted to know why it failed. And because you got the two criterion that you can check with IES, criterion 1 which is CO<sub>2</sub> emissions check and criterion 3 the overheating check. So CO<sub>2</sub> emissions check with a 23.5% improvement over the notional building to achieve the target building is fine, that passed. I got involved because it failed on the overheating assessment; too much window area and too much IT in the rooms to cope without any air conditioning.

**IN: I assume that when it did pass, it eventually went to planning?**

I15: Well yes, I tend to lose contact with jobs after they pass. What we do is get it to a point to which it passes, get the BRUKL document (the building regulations UK Part L document) which the planners, building regs, building control want to see to say that it's passed not only criterion 1, which is the overall CO<sub>2</sub> emissions, but criterion 2 and 3 as well, which is the limitation on design flexibility and the overheating. So, we produce that, it would usually be within a larger report that we'd produce that. If it was required earlier than the big M&E or architectural report, it would go out as a standard loan Part L report document, that we'd send to in the first instance to the architect or lead designer who would then send it over to the client or any other consultancy that were engaged in the design. And then from there it would have an appendix-a BRUKL document-that would be the document sent over formally to the building control.

**IN: How were the different roles and responsibilities for each of the group members structured-I assume that like you mentioned they were all kept in company?**

I15: We didn't out source any of the drawings or the modelling make-up or anything else. We have done in the past. We have used mainly CAD resources, so we'd have drawings from the architect that we'd out source to a CAD resource and they'd send the CAD versions of the drawings. We haven't yet sent out IES models for the geometry to be in-filled because it's good experience for our junior modellers.

**IN: At which stage of the design process was the Part L2A compliance simulation exercise undertaken?**

I15: Well this was the problem because our architects are quite keen, and often go ahead and progress their designs to the Stage D or E and don't get the engineers involved till Stage C, which hence causes problems. So I think architecturally, this was at Stage D. And then we were trying to bring up the M&E to Stage C to catch up with the D. So, I guess you could say that it was at Stage C, pretty late, which can be frustrating especially when it's in-house and they sit around the corner. We try to address it in-house and are give seminars to the architects on how easy it is to get quick updates to engage engineers early, to make it more efficient, cost-effective, better design. It is a historical job, so we can't blame them if they didn't know any better.

**IN: Did you require any form, if any, of co-operation or help from other specialists? (For information, or undertaking the simulation)**

I15: I don't think we did on this project. We sometimes have glitches in the software and we go 'why doesn't it give this result or why isn't it doing this?' IES are generally quite good a coming back and saying it's because you didn't tick that box or generally sometimes it's because there's a problem with the software and we don't know what's happened, which is fine, because you haven't made a mistake. But in this instance, I don't think there was technical query from the modelling point of view that we had to get advice on.

**IN: In your opinion, was this the appropriate time to undertake the simulation exercise? (If No) At which**

110 **stage would you have preferred to undertake this and why?**

I15: I encourage all modellers to start modelling at the latest at Stage C. If they can get in at Stage B, then, that's great. One of the reasons people don't like to do that is that it can totally change and you can end up having to re-model and you've just got double the cost, double the modelling time, which is a real pain.

I mean you've got a bit of weight behind you if you haven't started modelling at Stage C, you can say hang on a minute, this isn't good practice you need to get it done, but B is ideal. The problem we have is the clients we have aren't that pushed to make the motivation of the design from the angle that you and I might look at it which is the energy efficiency, it's almost quite the opposite which is it to be totally functional and then if they can make any energy improvements, then fine. But that comes after they've got the core design working. So in this instance we did actually get the client who wanted no air-conditioning, which is good, but even though they said that, I'm not aware that they allowed any space or time within the designers to design for that.

120 So the architects would use their, they've got some, with Sketch-Up you can use your sunlight, so from their opinion if you could create brille soliels that could stop the high sun and actually visually stopped the light visually entering the window, that would mean it wouldn't overheat. And so there was a basic lack of understanding there, there's more to it. That's the peak sun, that's the brille soliel, it stops it therefore it shouldn't overheat. And it wasn't.

They did a previous building similar to this and the query was, it didn't overheat last time and that's because they put air conditioning in last time. So there was a real lack of knowledge about why things happen.

**IN: How much time (in man hours) was approximately spent on the simulation exercise in total?**

130 I15: Way too much. We had to remodel because it overheated because we weren't involved from the beginning. We used a junior modeller to create all the geometry so it took longer. I would say total he probably took – because we like to give them some space to try to work it out not for himself, but give advice rather than just steam roll in and make changes without explaining it to him, so it was a bit of a learning curve for him so we took a bit of a hit on that. I would say he was modelling for at least 40 hours and I gave maybe 10 hours of advice and maybe there was another 10 hours of other people chipping in. So, that would be 60 hours.

**IN: How did this vary from the time you initially planned to spend?**

140 I15: So, it could have really been done in less than 30 hours. And it makes a difference as well when it's your design. So the rest of the design, if we were just a modelling company we would have just sent it back and said you sort out your mess. So I guess within that time, it was the element of it's ours and it going to look bad on (the company) we'd better put an effort in making sure we're not letting our side down.

So we certainly do that with the EPC business, we've got a chap who just does EPCs and he's rolling EPCs out really quickly, because the onus is on the rest of the people involved; surveyors provide all the drawings. So if the core role was just model it, simulate it and send off the certificate, you can do that if you've got all the information in a couple of hours, less than 10 hours. So we did plan to spend the 60 hours, but that wasn't just doing the modelling, I suppose.

**IN: Once the model had been running properly, was the building able to achieve compliance from the initial 'compliance' run?**

I15: Yes.

**IN: What kind of measures did you use to achieve compliance? (Design changes or input parameters)**

150 I15: We had no problems with the CO2 emissions, so things like efficiencies of boilers or things like that we had less of a concern about. In fact, it was a fully electric building, which didn't help but they had air-source heat pump and it did pass. What we tried to do is change the shading coefficient of the windows (the G-value) to make it a solar glazing pane instead of the standard Part L glazing. The junior modeller (had) improved the U-value of the glazing, which made it worse because it was retaining more of the heat which we were trying to expel. So we put the U-value of the window back to the minimum allowed, increased the solar shading coefficient, the G-value, brought that down to 0.5 from the 0.64 that it would normally assume.

155 The architects revised the brille soliel slightly to reflect the more appropriate solution, so I think that it was slightly deeper. Then we had quite a bit of effort on the ventilation, introducing night-cooling to the building, but by agreeing there was high-level windows it could work on an automatic open/close safe secure function. Making sure that we were purging the building of warm air during the evening and night time. Made sure that there was some exposed concrete, I think that we were only to get concrete on the floor, we were only allowed to get thermal mass on the floor, I don't know if it was tiled or a stone floor, I can't remember. We couldn't get it on the ceiling because they wanted a false ceiling. So by including the night cooling, which we could only do with thermal dynamic simulation because SBEM wouldn't have been able to understand it, we

- 165 managed to get it to pass the overheating criterion via the IES way of calculating the overheating criteria, which is 1% of the time over 28°C for an office. And I think that we improved the lighting efficiency so there was less incidental gain from the light bulbs. Which infuriated the architects, because it was a relatively temporarily occupied build, although it was permanently occupied.
- I think that was pretty much what we had to do, and for one of the rooms we had to use the gains method for
- 170 overheating to prove compliance, which can't be used in the software. You have to manually calculate all of the gains entered into the room to make sure that there was less than 35 w/m<sup>2</sup>. So somebody worked out the solar gain, all the incidental gains in the rooms, all the internal gains to make sure that we were confident that it would achieve these 2 criteria. It was a bit of a strange one that we had to use 2 different methods to calculate that it wouldn't overheat. And the risk was an acceptable level.
- 175 **IN: Describe (approximately) the variability in results that was observed (in percentage).**
- I15: I think it reduced the (improvement % CO<sub>2</sub> on the notional) because we were no longer getting the useful winter solar gain. So we reduced the amount of solar gain that come through the window, so we had more heating load in the winter. But that was still able to pass, we had enough scope in there for it to pass. (The difference) was) not a huge amount. It wouldn't have been more than around 5%.
- 180 **IN: Which Input parameters did you observe as having the most affect on your results?**
- I15: The night-purging.
- IN: How did these results feedback back into informing the building design process? (or was is separate?)**
- I15: We can't change the glazing spec, unless you get it signed off from the architect, so they have to put it in their design specification. The night ventilation/purging system has to then be written in by the
- 185 mechanical engineer. So he was aware that that was the solution, so that's what he wrote into his specification and designs.
- IN: So did these become part of the design?**
- I15: You can play round with your building all you want but unless you did something acceptable in terms of cost or design.
- 190 **IN: Are you formally accredited to carry out Part L2A compliance calculations? What route did you follow to submit you work?**
- I15: Yes (LCC)
- IN: Did you use any internal methods to assure quality control and the validity of your results? Please describe these methods**
- 195 I15: Yes, we will always get it QA-ed. We have an internal QA sheet that one of our senior chaps has put together and it's got a basic list of checks. So once say I did a model and I got it to a point where I think it passed, I would hand it over to somebody else who was accredited and they would check my model. They'd go into the settings, go into the geometry, look into the systems and they'd basically ask a lot of questions if things didn't add up, do a couple of sanity checks and things. So that would always happen by somebody
- 200 who was quality assured by LCC. Because often we have people who aren't accredited to build the design and train them up to (be) ready to take the LCC exams. So we want to give them live models to work on, and once they've got it to a point, they have to then hand it over to somebody who's accredited to check that everything's correct basically.
- IN: So an internal QA system, where somebody checks somebody's work?**
- 205 I15: Yes, totally internal, we don't use another company to check.
- IN: Did your building pass with regard to the requirements of building control**
- I15: I handed it over to the design team and they haven't got back to me.
- IN: Did any of your team have any contact or interaction with Building Control?**
- 210 I15: No, it's something I encourage them to do at the point at which it failed the overheating test and the suggestion from the senior engineer to use the other method of compliance – I used the simulation to pass the overheating criteria and there was this one room where we used the gains method- and I thought that that was a little bit odd having to use two different methods, so I suggested let's just ask building control, they'll be quite reasonable. I'm sure. But it was deemed that it wasn't necessary, so we didn't contact them at all.
- IN: What are the main issues, if any, did you encounter during the simulation process? Please describe these issues.**
- 215 I15: The general process on this particular model is interesting because, in my opinion, it wasn't approached in the right way. We got involved too late, there was no communication about why it was failing initially, after I was brought on board, which is no reason that they couldn't have popped their head around and said 'it is failing because of this'. So a little bit of an internal lack of communication between the designers and the

220 modellers, which really wasn't necessary, that should have been picked up by the forms that we use to communicate. So that was an issue.

So the other issue was that it was quite complicated to use the night purge profiles, because you are writing them based on your experience on how to get a model through overheating checks, which may or may not actually reflect a good way of operating a building. We're assuming now that they have to install these  
225 automatic dampers on their high-level windows to make sure that they've got sufficient cross flow of air in the evenings to purge the air. That may happen, something might go wrong with it, it's relying on a system which could fail or could be chapped out because of costs reasons further down the line and they wouldn't tell anyone and then it gets really hot. So there's no check up on if these things really get done, although they're in our designs, the contractor could easily take them out.

230 The other thing is that we know that that building is relatively infrequently occupied, although it's technically occupied heated space. To go through all that effort just to get it to pass because it was failing by a couple of percent, probably I think if we'd contacted building control, they would've just said that's fine because they know it's relatively infrequently occupied and that's only going to happen a couple of days of the year, which it may not even be used. So it was frustrating for the architects because they'd not realised that it would be a  
235 problem and it's frustrating for the modeller because it's taking so long to do something which is probably not even going to make too much of a difference because maybe one day a year it's unhealthily hot. In this instance we got it to pass, we got the risk of overheating down quite low to an acceptable level which has been decided upon. So that's just somebody deciding on that level, there's no account of saying well if you allow for the clothing value of people on those days, the tolerance actually increases, we're going to allow you to be  
240 over 28°C for 2% of the year. And there's no flexibility for allowing for social adaptability to the internal conditions of the space for the overheating.

And also it's a fully electric building and it passed building control, building regs. To me that's interesting that you can get a building which is fully electric to pass when really that's quite a high use of a, the fuel is quite carbon intensive really, so they should be looking at other things may be.

245 **IN: Which would you regard as the main priority for consideration in future Part L2A revisions. How would you recommend that these issues be dealt with?**

I15: I think that flexibility for the overheating criteria would be quite useful. I think generally, it's quite easy to pass although it wasn't an issue and everybody was up in arms saying no way we'll achieve this, when really it's quite easy to pass.

250 **IN: With regard to the methodology, NCM?**

I15: It's quite easy for a cement factory to pass Part L with flying colours, but it's operational use is excessively dirty. Then you're getting into a different realm of what you're trying to assess and what are you trying to achieve. Yes, it is a bit disappointing that you can get any building to pass, if you know what you're doing and you've got a scope within your team to advise, just have lower lighting efficiencies. Including air  
255 conditioning makes it easier to pass because although you need to increase the amount by which you improve over the target building to 28%, because the notional building is using a much worse air conditioning system than you can specify, it's easy to pass with an air conditioned building, which is a little bit counter-intuitive. So that's a little bit strange.

I guess it can also be quite frustrating for people to use the NCM especially for example the building that  
260 we've just talked about, we had to assume that it was occupied based on the occupancy of the NCM rather than the actual amount that it is occupied. So it's not going to reflect reality. I think it's quite difficult to include flexibility, but then how else would you do it? There's a lot of problems with it, but it's a good effort, I think.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

265 I15: Well, the energy efficiency of buildings have definitely been improved through Part L, the more stringent that becomes, that's the bottom line, that's what our designers design to. Whether or not they say they're ethical, they're wilfully responsible. They build to the cheapest they can build and the minimum standard is Part L so that's what they design to. There's so many buildings we see, where if they'd spent a fraction of what they're spending on this fancy cladding we could have saved tons and tons of carbon, so there's no incentive  
270 to go beyond it, in a sense. They get to a point and then they stop.

I think that EPCs in a way make people aspire to get an A, I mean I don't know if that is happening or not, but I think it just needs to keep on getting ramped up because people have to take notice to it and they have to actually comply with it.

## 2-Building Control Body Interview Transcripts

Table A-D.2 outlines the details of the building control interviews. For each interview, an assigned interview code was used where the letter *B* (to denote *building control interview*), as well as the number representative of the order in which the interview took place (e.g., BI01 for the first interview) were used to differentiate between the interviews and maintain participant anonymity.

Table A-D.2: Building Control interviews

	Organisational Role	Job Description	Qualifications	Experience
<b>BI01</b>	District Building Control Surveyor	N/A	MBEng	25 Years
<b>BI02</b>	Building Control	Director	MRICS	25 Years
<b>BI03</b>	Building Control Surveyor	Surveyor	MRICS. BSc. BSc	5 years
<b>BI04</b>	Regional Manager	Approved Inspector	RICS, MBEng, DMS	32 Years
<b>BI05</b>	Team Leader	Building Control	BSc (Hons) MBEng	22 Years
<b>BI06*</b>	Director/N/A	Business Development Director/Managing Surveyor	MBEng/MBEng	20 Years/ 23 Years
<b>BI07</b>	Building Control AI	Surveyor	MRICS/MBEng	20 Years
<b>BI08*</b>	Ass. Building Control Officer/Building Control Manager	N/A	BSc Building Surveying/N/A	1 Year/ N/A
<b>BI09</b>	N/A	Building Control	BEng/MEng	20 Years
<b>BI10</b>	Senior Building Control Surveyor	N/A	ABE Surveying	35 Years

\* In these interviews, two participants took part. These are referred to separately in the text (B0x-A and B0x-B)



## B Interview 01 Transcript

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI01: On new Part L? Most of our work is housing obviously, the sort you get in any London Borough. We do get a few large projects for the L2s. A community centre, I've just recently done a nursing home. It's still in the process of SBEM testing, so we're still waiting for the calculations for that one. We've had preliminary meetings about the roofing over the town centre, the roofing of our existing shopping centre, so it's going from external to internal. We're due for the application coming in shortly, also we've had descriptions about the refurbishment of the central library, refurbishment and extension of the central library.

**IN: That would be Part L2B then?**

BI01: Not so much new work as much, a lot of refurbishment and extension as such. It's not massive, things like a school gymnasium, so they are fairly smallish projects

**IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

BI01: It would be checking plans for compliance to building regulations and obviously taking the documentation for SBEM. Normally we just check to make sure that it's been done by an accredited person. If it's been done by an accredited person, we accept it and just check to make sure he's made a right assumption on the U-Value of the wall or the specification gone in, then obviously once that's been done before the work starts-which is a rarity these days- we inspect on site to check what they've done on the plans is what they're building on site.

**IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006? Did you receive any training with regard to the new technical requirements of the Part L2A amendments?**

BI01: Well, we all went on training courses. Every inspector was sent on a two-day course by the RICS and ABE. We used to have an officer who was able to do SAPs and was quite experienced in that.

**IN: For residential?**

BI01: There was one gentleman who left unfortunately, we're waiting for someone else to go on a training course so he can do SAP calculations and check. So we've got no one who can really check the computer programs. We tend to have to sort of as it is. If it's been done by an accredited person, then probably we're not going to check that. We are looking for the general criteria to meet the minimum U-Values and backstop values and so on and so forth, so we've got sort of general knowledge, not specific knowledge of the actual process of creating the SBEM calculations.

**IN: So with regard to the training you mentioned, you don't specifically do SBEM, but you know of the procedures involved.**

BI01: Yes

**IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance?**

BI01: I think it makes our job easy, because it's fairly straight forward. Before you'd go through, you'd be checking the window areas, you'd be checking the floor areas, you'd be checking the insulation values and now you've got a document that says well it's a pass or fail. All we do, as I said, is check to make sure what they show on the plans in the wall constructions is what they specified in the SBEM calculation and it's what is on site, once we go on site. It makes it easy for plan checking, but makes it difficult for site checking because often, this is for residential more than commercial, if they want to do a minor change on-site, they obviously have to back and recalculate the whole process, or potentially go back through the whole process and recalculate it.

**IN: But SAP would be easier to do than SBEM.**

BI01: Yes, but that's the thing, I always make sure with the SBEM they've chosen the right purpose group for the use they're doing. I've had a community centre, they've done that as a sports centre and they've gotten back to me and said actually, well the reason for that was that it was on sport's grounds but it's also got community halls. So it's a matter of deciding which category it's going to. Once that's all in, for us it's pretty simple because you're given a document that says it passes or fails.

**IN: So what about the use of simulation tools in general for compliance demonstration, do you think that's effective?**

BI01: Depends you mean by that, what sort of computer?

**IN: SBEM is a calculation tool there are other tools that they use.**

BI01: I haven't seen any, I've only seen SBEM.

**IN: You've only dealt with projects with SBEM.**

BI01: Yes.

55 **IN: There are other tools like IES and other dynamic thermal modelling tools.**

BI01: I've heard of them, yes, but we've not had anything around here.

**IN: So basically it's SBEM?**

BI01: I've been on a refresher course, where for buildings like the Gherkin where it's all glass and you use dynamic modelling – obviously it warms up rather than cools down, but around here we've never had projects of that sort around here, as it were.

60 **IN: At which stage of the design process does your involvement usually begin?**

BI01: It would depend really, obviously on the designer. I mean on the bigger projects, obviously, we tend to have preliminary meetings. We have early meetings with the designers and go through what we're looking for. Often with the smaller ones, the smaller commercial stuff we get, especially with the local architects- for the lack of a better word-they're not even aware where the rules have changed sometimes.

65 **IN: Are they not?**

BI01: They tend to use us as a learning process, I mean they'll send us the drawings and we'll do the initial planning check and I'll say 'have you done the SBEM check?' and they'll say 'well what's that?' and you know you've sent the drawing and reviewed these walls 'so what this going to be like?'. 'I don't know that'. I can say well go off and get the appropriate commercial advice, so it's a situation of where we're leading them rather than them leading us. Instead of them coming and saying 'we want to do this, this and this', they're coming along to planning and not knowing that they've got to do SBEM calculations.

**IN: Do you think involvement at this stage is effective in ensuring Part L2A compliance?**

BI01: It certainly is, yes.

75 **IN: Please describe the impact of your involvement on the development of projects.**

BI01: We've not had any large projects, I mean we'd just be looking at that. The other thing we do at the final stages is look at what has been approved in the plans and what's left to be done. It's considerably difficult for them to get improvements on that because obviously it's they're knocking walls down and rebuilding partly, it was decided if it was new or old. Our planning department also made a requirement of getting 10% energy from renewable resources as part of the planning approval, but of course they can't – in the middle of Romford- they can't get that 10% either. So we've got our planning department, our energy consultant, well, theirs and myself, we had a meeting with them – the developers- and said perhaps we can do a better heating system upfront rather than try and tag on to the other buildings, which you're not really going to be able to do- is to try to use more efficient plant or not use any cooling plant at all. And the idea is to have a – there's a big problem with the one down there of overheating when it was originally roofed over. When you look at it for all intents and purposes there's a massive amount of fans for smoke extraction when there's a fire and they're using that to cool the building down. So the new extension, they're going to vent naturally using stack ventilation systems to avoid overheating and to avoid any additional air-conditioning to cool it down. So we've agreed in principal rather than having consequential improvements which they can't get, to spend some of the project money and get a better building to start with. So it's that sort of impact more than just saying to them you've got to give us this.

**IN: So it was design guidance?**

BI01: Not so much design as what we'd like to see as advise them how to do it. It's much better than tacking on the, the end, tacking on the end of the job, try to do something at the beginning, try to do something more energy efficient now. We are able to negotiate with our planning department, so we say look it's not really an energy efficient building because you can't achieve the 10% from a renewable energy source, let's not have that.

**IN: So it's a trade-off?**

BI01: A trade-off with the planning department. We say well you can't have 10% renewable because you can't really- well you can put a few solar panels on the roof or you can put a windmill on the roof which is not going to happen, so we're going to help with solve some other issues that relate to the planning law.

**IN: Who is your usual point of contact on projects?**

BI01: It would normally be the architect.

**IN: Do you view this to be the ideal person to interface with?**

105 BI01: Well, I wouldn't say architects, because some of the jobs we get some people are not even aware of the legislative changes. Obviously, with a large project like this, there's a major architect that has got an energy consultant on board from the preliminary stage. But on the smaller jobs that you do, I mean many are design-build. So that was a contractor who did the design build and they didn't have any skill at all, and you say well we can't check these drawings because we don't know what the use is, what's your heating equipment, what

110 air conditioning plant you put in. So it's not the best. On one or two h occasions when you have an energy consultant on board, when you speak to them, they are quite aware of the regulations, they know there's got to be work.

**IN: So it makes things easier when there's an energy consultant?**

BI01: Certainly, because they're sort of leading the architects and we just tell them what you need to do is this.

115 With the design they know you need to put these levels of insulation in or avoid this and that.

**IN: So are architects aren't the people responsible for Part L2A compliance work?**

BI01: No, not on the ones I've done, no.

**IN: You mentioned that most of the projects you worked on used SBEM.**

BI01: Yes

120 **IN: With regard to Part L2A compliance, what kind of information do you require to be submitted?**

BI01: Well we check it and see what they've assumed for the usage to make sure that we're happy with it, what they've allowed for the insulation. I don't take it for face value, we take it and check it against what they say in the drawings so you know you'll get the same building. And obviously at the end of the job we look for if the insulation testing is complete, the commission certificates, the lighting...

125 **IN: So they systems as well, the requirements.**

BI01: Yes

**IN: Do you require that they submitting the Part L2A work be certified under either of the accreditation schemes?**

BI01: Yes, we would expect that, yes.

130 **IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route?**

BI01: Not as far as I know, I haven't no.

**IN: What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?**

135 BI01: Again we look to make sure that they're from accredited companies. We only accept that at the end of the day. We've never had the issue when it hasn't come from an accredited company. So as long as they're on the accredited list of AIC, NIC, BESTA or something like that, they're accredited, we just haven't got that kind of backup to start to independently check that.

**IN: The accreditation you mentioned would be the accreditation of the company?**

140 BI01: If it was an air-conditioning plant or a heating plant, we'd make sure that it was installed by a certified person.

**IN: With regard to the Part L2A calculation, you know the person has to be certified with either the BRE system of the CIBSE system?**

BI01: Yes.

145 **IN: So you require them to be certified with that?**

BI01: Yes.

**IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**

150 BI01: Honestly, I can say with most inspectors we never used to treat it that seriously. If the buildings taking up a bit more heat, nobody's going to notice and no one is going to die if the building costs £50 more a year to heat it than it would do if you done it properly. So I think that was the mentality perhaps a few years ago. I think with the Part L changes that have come in, it's sort of, almost sort of every time you go to a seminar or course it's much more, you have to take it more seriously than you have been. So personally, I think we take it a lot more seriously than we used to. 2 or 3 years ago that, probably wouldn't have been the case, you would have thought fire safety, have you got safety glass, stuff like that was a lot more important. Now you take it a lot more seriously making sure that it does comply and getting on top of it at an early stage does help it and at the start to make sure it does comply with permeability and air tests and checking insulation. It's not a statutory inspection, but we make sure we do all site inspections to make sure that the insulation goes in at the right stage, at the right places and at the end of the day you do the air permeability test and it's ok on that and have an audit at the end of the job saying it all gone in and there's a formal certificate now and you do take it more seriously than we once did. It has changed.

**IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?**

160 BI01: Oh yes. We don't have statutory inspection for insulation, if you don't see the insulation go in, you don't

165 know what's probably in there, when you do come back, especially then when you have a drawing and the specs are different, you can go back and say 'you've changed the insulation, so now what are you going to do with the SBEM calculation, are you going to put the insulation back?'. That's across sort of both commercial and new housing, because we obviously do a lot more new housing, but we do make sure they put the right in, the right number of emergency lights. As I said we don't do a lot of commercial, but we do the same sort of  
 170 thing we go there and inspect to make sure if there's been emergency light fittings put in, that we do have all the information on the heating plant, they've got the manuals on how to use it properly so we get all that completion information and we're satisfied that it's all there.

**IN: So you think when all these checks are put in place are very important?**

175 BI01: Well, we've got several people here for the inspections who deal with the insulation, it's not a statutory inspection, so it may well be that the other councils don't do the inspections and it because it may well be inspected when you go and see the structure, that you go and see the insulation.

**IN: Are there basic checks that are expected across the board for all building control?**

BI01: I don't know, that would depend on the sort of service they would do each.

**IN: So it varies then?**

180 BI01: I mean, I don't know but that's expected from the inspectors that come here.

**IN: What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance?**

BI01: For problems on site?

185 **IN: Problems on site or problems in submission and you mentioned that people don't even know of regulations.**

BI01: Yes. You're getting a building when the work's done on site prior to the plan being approved, prior to the SBEM calculation being carried out, so you know you're going on site and you say 'you might not get compliance here. It seems fortunately that most do, is it because they massage the figures, I don't know, but most seem to you go on site and they haven't gotten approval yet, most people start out without approval and  
 190 you write to the architects and you say well where's your SBEM calculation?. 'What's that, I don't know?' 'Well you might have to put more insulation in your walls or more insulation in your floor. And you've got certain money for this project and how are you going to achieve it?' 'Don't know'. So that's the biggest problem.

**IN: So the lack of information?**

195 BI01: It is, it probably is better now than it was, but the first couple of years it came in it was a hell of a lot of jobs that, these people just didn't appreciate that the rules were changing-I presume the RICS do contact them with regard to the regulation change, we know about it, but they don't seem to bother. A lot of architects, smaller architects and smaller agents probably rely on the local authorities or their own inspector to educate them. So they'll put a plan in and get a letter then say well ok what have we got to do now?

200 **IN: So it's always in retrospect?**

BI01: I think a lot of agents, they will tend to have the situation where they will be led by the local authorities to actually bring them up to the current standards. They will come in and we'll say 'this is what we asked for' and they'll say 'alright where does that come from?' Then you recommend a company that does it. They say 'who does it' and we say 'well we can't recommend anybody', we say go on to websites, CLG websites and  
 205 find somebody who is accredited to do the calculation for them. Not all our agents to be fair are architects, some are surveyors, some are what one of my colleagues describes as plansmiths, they've got no formal qualifications for architects, they just produce plans.

**IN: Is that on smaller build?**

210 BI01: No, they will produce plans for the large schemes, not many of them, but some of them will produce schemes that will require a SBEM calculation and be fairly fearless. A couple of them are design-build so they have the world experience- who's doing their drawing if its and architect or surveyor or something like that, you know. It's surprising that, there are some good architects out there who are aware of the regulations and who will get someone in and some will just stick their head in the sand and wait.

**IN: For building control?**

215 BI01: Yes.

**IN: What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision and how would you recommend that these be dealt with?**

BI01: I've not really read that.

**IN: Based on your previous experience with Part L2A work, are there things you think they should**

220 **improve?**

BI01: It appears now that the methodology is working reasonably well, so really it would only be the increase in the figures that they're looking at again for more efficient buildings to make sure that's sort of pushed to the architects and surveyors. But I don't think that the methodology should change. It seems to me it works, in a way it's made it easier for building control for checking plans, but it's not so easy to check on site. The problem with the SBEM system is being allowed to make changes on site easily. You put a window here or another door here, then you have to presumably go back and recheck that because they've made that change. Where before we would just, the old method it was done on the elemental method, we'd check the glazing allowances to see if it's fine. Don't worry about it at all.

**IN: The elemental method gave you the opportunity to have a lot of feedback on site?**

230 BI01: Yes, before it changed we would be looking at just the percentage of glazing and they would say 'can we change that and put in a window now?' When we'd done the original check, we would have sort of made sure what sort of glazing it was and make a note of that in the file, but they come along and say can we increase it and if it was with the 25% or 20% or whatever you were allowed we'd say no problem.

**IN: How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period)**

235 BI01: I mean every 4 or 5 years, there's tons of regulations now. I mean now I'm mostly office based and checking plans and you find now that a few years ago when the regulations were slower to change, not just Part L, but the whole building regulations – as I say because a lot of plansmiths tend to be led by us, they learn and their plans get to a certain level and we approve most plans on the first check and give conditional approval, now because they're changing so often you're not approving plans at all you're just going back with one letter, two letter to 8 or 9 plus because they're not catching up. So in my view, it would be they should review perhaps less. Obviously, I mean if you're going to be sort of meeting European targets you have to increase them, but it would be a lot better if they could review a lot less and even if they do, review them all at the same time. I think we're talking about the last year the regulations changed in April and October, but it's not just Part L, they'll change Part B, they change this and they'll change that. So every year it'll be new regulations and something else. And our, I won't use the word architects, our agents they can't keep up.

245 What'll happen is we'll write a list of comments and they don't bother, they certainly won't go on training courses, they will just wait when planning to get back with a plan with 5 or 6 points on it and they ask about those points and then that's their training. And the next year, when the regulations changes, same thing, that's their training. At the moment, they change so often, the regulations that you're constantly back and forth with letters and that's the way they do it.

**IN: And do you think they should expand the standstill period between the time they introduce the regulations and the time they actually come into force.**

255 BI01: That's not an issue. When they introduce these transitional provisions that's what causes the confusion, because we've had the situation where I know from work in my experience and from others that they ignore the sort of transitional period where it's got to be pre-approved where –this is to do with Part L, if you approved the designs, which is perfectly alright and it's got a conditional approval – when the approval comes in you're supposed to write to this person and say well your designs are all rubbish because you haven't got full approval, you haven't started work on site according to the new Part L, when all they were waiting for was a conditional approval on the roof trusses, which has nothing to do with the thermal condition of the building. So if they had accepted the drawings with the truss details it would have been ok. So I think that there's, with regard to the conditional provisions as long as they deal on the fabric, if the glazing was put in, deal with if the boiler is there and is supplied, then that's ok, but if the condition is completely unrelated to the changing regulations, then it's a bit nonsense. With Part B they did go back to the old one for everything that was submitted before the building regulations changes. But there is, you know a sort of nonsense where you know they've got it fully approved and where the condition is completely irrelevant, the plans had been approved for a year, perhaps a year and a half and the condition could be completely irrelevant to Part L, and other regulation could be completely irrelevant, we've had something change with Part M and –solar access– and it's loads of work, changed the whole design of the building after it had been agreed subject to submitting some details you can't till you start work on site, you can't get details from the truss company till put in your order. You don't know the details of the truss till you pay the deposit. I know that other councils have just ignored those changes and have given the benefit of the doubt and say no we're not going to pursue it.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

270 BI01: Personally, I think the procedure is fine, it just needs to be pushed more and more perhaps, I mean we

275 don't have any, I mean they must see professional magazines and know what's happening about that. I think  
the procedure now is quite ok, I think there should be perhaps, I know we're looking for the competent,  
approved inspectors its always connected to the level of service that they provide. But at the moment if you  
start not to expect any inspection, you start to not to expect to do that. So in my view, if you're going to have  
these regulations in place to make sure levels of insulation are put in and energy efficient lighting is put in, it  
280 should become a statutory inspection. There's no point of having them do SBEM calculations and then you  
don't go on site and inspect it and make sure they do it. Because they're going to come back and say 'well, yes  
we put insulation in'.

**IN: So, it's a matter of its good to have them in place, but it's better to have tools to enforce them.**

285 BI01: Yes, we certainly have the requirement to inspect. At the moment, we're going through a process of sort  
of having a surveyor everyday talk about the way they work and looking for savings-as usual with all  
councils- the question is when do we do the site inspections. Well if you have a manager who's not building  
control , we have a director who's in finance who's not building control , 'why are you doing these  
inspections, it's not a requirement. It's costing me £20 every time you go out to do inspections. You've got to  
stop that'. So it seems there needs to be a sort of argument about the statutory requirement to make  
290 inspections. There's no requirement to make inspections, the only requirement is to check a plan and give a  
decision in a certain period of time you've got to make an inspection with the builder and the contractor have  
to notify us if we've got to go and inspect that, there's no legal requirement for a building inspector. Perhaps  
there should be a legal requirement that an inspection should be made. We'd all have to do that work and  
inspect it. But if you're making lots of regulations to put insulation in lots of systems in to make a building  
295 more efficient then it seems a bit pointless if you don't go and inspect them.

**IN: So it's basically translating what you have on paper to reality?**

BI01: Yes.

## B Interview 02 Transcript

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI02: Right, (the company) deal(s) with mainly commercial projects. We deal with projects having a value, for example, of in between 1 million and circa 30-40 million pounds. That would encompass a range of different projects, a lot of schools for example, offices, museums, some hospital-type premises, university buildings and retail.

**IN: So the whole range of commercial projects then?**

BI02: I'd say a pretty comprehensive range of commercial-type projects.

**IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

BI02: My role, I'm a director with (the company). So I head up the building control section. I do deal with projects on my own as such, usually the larger type projects. Other projects are given out to surveyors depending on their experience and obviously, I keep an eye on how they are proceeding with those projects. If they have any queries then they come to see me to ask whatever questions they may have.

**IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006?**

BI02: No significant changes. What happened with the L2, as you're probably aware, is that they produced a training disc, the RICS produced the training disc which we all received a copy of, and ran through that to look at the various examples that were shown on the disc for application of Part L2 projects. We also-not specifically for L2-but we also took on a services consultant in the company who is trained in the use of the relevant L2 software.

**IN: So it was a sort internal training program then, or an internal consultant?**

BI02: There was internal training so as far as the surveyors were concerned, but our services consultant, he went on an external training course. I think some of us also went on external training courses just thinking about it by the likes of mid-career college who offered L2 training courses, and also the RICS.

**IN: And these were usually 2-3 day training courses?**

BI02: I'd say that they were just day courses.

**IN: What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?**

BI02: The only person who has a sort of in depth knowledge of the mechanisms within the software as such would be our services consultant. Our other guys would generally be familiar with the output side of things, so looking at the BRUKL document for example and the information contained on there. But behind that we're not particularly familiar with it.

**IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance?**

BI02: A difficult one. OK, I said the information that comes together in the BRUKL that is what we would look at.

**IN: And that is pretty clear?**

BI02: We think that document's fairly clear, yes. We don't have any problem with the format of that document. And obviously, we look at the key information on that relating to targets and actual figures for carbon emissions and we also look at who's produced the document to make sure that we're happy with the source of it and we will evaluate compliance based on that document.

**IN: At which stage of the design process does your involvement usually begin?**

BI02: As a company relating to a project generally?

**IN: Yes.**

BI02: It does vary. We find we're taken on board possibly before RIBA Stage D, usually not before Stage C, I would say. Particularly on large projects, people will try to get you involved earlier so that you are helping in the design development of the project. I think that's one of the sort of the key advantages of using AIs, they can become involved with projects at an early stage. Some people do leave it later, undoubtedly, and Stage D will have gone through its review, planning application submitted...etc. And the later you get involved with projects, obviously the more difficult it is to have useful input to ensure building regulation compliance. You tend to be dealing with more of a 'fait accompli', which can be quite difficult at times.

**IN: So you would prefer to be involved at earlier stages?**

BI02: The earlier we're involved the better. And prior to Stage D is- as far as we're concerned- quite beneficial.

**IN: Please describe the impact of your involvement on the development of projects.**

BI02: On the development? Again the earlier we are involved with projects, then you can make sure that the project moves in the right direction for building regulations compliance. You can help the architects and the

55 design team, well prevent them going down dead-end avenues with regard to compliance...etc. So I think the earlier we're involved, the more value we can add to projects in making sure that you're taking the shortest route to compliance.

**IN: And would that take on the form of for instance, design guidance for the architects as well?**

60 BI02: As a building control body, you can't actually say you offer design guidance because it conflicts with our role, but what we do tend to do is attend design team meetings, so we can look at what's been offered and state our view on the state of the design with regard to compliance and you can steer people without it actually being called design guidance, you can steer people towards solutions that they may not have thought of or solutions that are compliant ...etc. So whilst you can't say that it was actually design guidance, you do help to assist people in getting to a solution and you can explore either side of that line to look at other solutions as well.

**IN: Who is your usual point of contact on projects?**

65 BI02: Usual point of contact would be the architect. Might also get involved with the project manager. But the most useful point of contact and the most productive point of contact, is usually with the architect or the designer.

70 **IN: Are they the person responsible for the Part L2A compliance simulation/calculation work?**

BI02: Not necessarily. They might be the person we ask for it. But so far as it's issue is concerned, that would be something that would be within the design team or it might come from another party like, for example, the services consultant...etc.

**IN: Or an energy consultant?**

75 BI02: Or an energy consultant, yes.

**IN: Which calculation tools/ methods are most frequently used to carry out this work?**

BI02: It's either been the SBEM or the Tas procedure. We have seen IES as well, yes.

**IN: With regard to Part L2A compliance, what kind of information do you require to be submitted?**

80 BI02: We look for them to provide the information that's cited in the BRUKL. We don't ask for the actual calculation, although sometimes we do receive it. We would be happy with the information that's detailed in the BRUKL document in terms of the actual calculation outputs, U-Values, the solar shading analyses, and then obviously the more construction based issues and then finally the commissioning items.

**IN: Do you require any specific details with regard to the HVAC systems?**

85 BI02: We do ask for the actual services design as shown on the consultant's drawings and we ask for calculations relevant to the Part L for plant and performance. We do refer to the ND-HVAC guide to make sure that plant is efficient in terms of the ND-HVAC guide. And that's when we start using our in-house consultant to help us out with that.

**IN: Do you require that they submitting the Part L2A work be certified under either of the accreditation schemes?**

90 BI02: We do our best to make sure that they are certified, yes.

**IN: If not, how do you gauge their competency?**

BI02: We have come across that once or twice and what we have done on those occasions is ask for the calculation in full to be submitted so we can have it checked by our services consultant.

**IN: So you do an in-house check an in-house revision for their work?**

95 BI02: We'll look at it in-house, yes.

**IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route?**

100 BI02: I can't actually recall to date that we have actually done that. We generally try to be fairly insistent that they give us the BRUKL. I think I might've seen one or two template forms of it, but generally speaking I would say it follows the actual layout and format of information required by the BRUKL.

**IN: For some things like for instance overheating, some consultants have their own spreadsheets or methods for calculation. You've never come across that?**

BI02: We have yes, we've come across-I can't remember names of any particular software at the moment-but we have had analyses for solar shading.

105 **IN: What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?**

BI02: Well, other than the actual surveyors doing the project checking the BRUKL document themselves and as I said, trying to verify the people producing the information are certificated and then if they're not, running it past our services consultant. We don't do anything else in addition to that.



110 **IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**

BI02: Right, we see 3 of the approved document as being key to a project and that's the fire safety, accessibility and Part L. So it's up there in the top three as far as we're concerned and obviously it's an important issue.

**IN: Has that changed recently or was it always something that you always prioritised here at the company.**

115 BI02: It's undoubtedly increased or improved in its profile in terms of its importance as such since this company was formed 6 years ago the introduction of Part L2 did a lot to focus time and energy spent on ensuring compliance. And therefore, yes it has gone up the scale somewhat.

**IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?**

120 BI02: What in terms of the plan checking side, or the site side, or both?

**IN: Everything.**

BI02: OK, I think I probably said how much we deal with the actual paperwork side in trying to ensure that we have a building that on paper complies and then obviously we carry out site inspections to ensure that the work on site complies as far as we're aware. And then as a project approaches completion, we do ask the

125 contractors to provide us with confirmations in the form of commissioning certification and the Regulation 16 Statement with regard to the works that have been carried out meeting the design philosophy as such.

**IN: So you follow through to the end of the project to make sure whatever is on paper is translated into reality?**

BI02: Yes we do and we ask for the as-built BRUKL as well.

130 **IN: What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance?**

BI02: The BRUKL document, one of the things it does, what people do with that document is refer to information to be submitted by a contractor or whoever, and we do have difficulty tying up those parts at the end of a project. And it always seems to me that when you're asking people for that information, which

135 someone recognised needs to be provided, you get stonewalled a little bit. People find it difficult to provide that sort of supplementary information. I don't know if that's a case of it's not there or whether they can't be bothered. I've got the feeling that's it's probably the latter but I'm sure you know examples of the information it refers to, like the lighting it might pull that out as a separate design calculation to be required. And there is undoubtedly inertia in actually submitting that information to complete the content of the BRUKL. I think

140 people also have a problem with providing us with the statement of confirmation that the works comply with the design intent. That's possibly because, now why would that be, again I think it's inertia on the part of the main contractor. They've probably done the work they need to do, it's just converting that into writing. They've probably done it in terms of all the commissioning they've carried out. And it's just actually signing it off for our purposes to give us that confirmation that we require.

145 **IN: What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision? And how would you recommend that these be dealt with?**

BI02: What I have heard is that the, certainly the SBEM calculation is quite difficult to suit all circumstances. It doesn't seem to be flexible enough to deal with the way we build these days. So I think there must be a better way of doing a calculation or providing the basis for a calculation to actually show compliance. I also think it's

150 pretty meaningless to the people on-site, what these figures actually mean and because people don't- I think- understand that, that's probably another reason why we find it difficult to be provided with the information. I also heard something interesting this morning that on a school project we've had, we had requested the SBEM early on in the design because the way we sell that to people is that if you can make sure that the design complies using SBEM now and you don't do anything that's making the situation any worse, the SBEM that

155 you produce at the end of the job should still show compliance. And I heard that someone was charging about £1000 just to re-run a calculation and even I know with my limited knowledge you might only be having to change one or two bits of data and it doesn't take a £1000 worth to time to actually re-run it. So I think that sort of thing is also hindering the process as such to establish compliance.

**IN: How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period)**

160 BI02: I'm personally happy with that. I think people are under an illusion sometimes that the regulations or the approved documents change more frequently. I think they think they change more frequently than they actually do. I think in order to maintain progress with change I think the documents need to be reviewed every sort of 3 to 6 years anyway. I feel quite comfortable with that.

165 **IN: Do you think industry is able to catch up?**

BI02: Provided the documents are introduced in the right way, I don't see why not. I mean the introduction of Part L was an absolute fiasco. People just didn't have time to assimilate it quickly enough before it actually came into force. So provided the government introduced the documents in the way they say they're going to, i.e. giving a sort of 6 month lead-in, I see that as a problem that should certainly be capable of being dealt with.

170 **IN: So you think a sort of 6 moth standstill period would be sufficient?**

BI02: I think it should be, yes.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

175 BI02: I sometimes wonder whether we can tie up more with the energy performance certificate and the procedure for that. I mean it comes out of the calculations that are done anyway. But there's now obviously a requirement for EPCs when you're carrying out certain building work and I wonder if that might be a way of actually helping to demonstrate compliance with building regulations. I think the SBEM in particular-I'm not familiar with the mechanisms behind Tas and IES-but the SBEM does seem incredibly difficult to use. I think that's not so much the case with the other two bits of software from feedback I've obtained from services consultants. The feedback on SBEM is not good, basically. So anything we can do to improve that the better, or  
180 look at the other two programs and the way they work with actual modelling then as such.

**IN: So it's basically the programs and tying that with the EPCs**

BI02: I was wondering whether the EPCs might be another way to go. You know you look at the actual outputs of the EPCs at the end of a job, I suppose the regulatory problem is that that they are not required on all sorts of work we do but have Part L involvement. I suppose that would be an issue at the moment.

185

### B Interview 03 Transcript

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI03: Most of the surveyors like myself, deal with most of the projects that are available out there. So it's actually from commercial to residential, new build and existing buildings, extensions etc. So it's actually a wide range of both new and domestic, new and existing-domestic and commercial projects.

5 **IN: With regard to commercial projects what kind of building types do you deal with?**

BI03: Basically shops, retail, office-basically all ranges. We can actually do everything, but I've done most of the ones we get here.

**IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

10 BI03: Basically the scope of role and responsibilities that we have as building control and obviously myself included is to ensure compliance to the building regulations. That includes plan-checking of plans at a very early stage, offering comments to the client and the various consultants on projects. This also includes us carrying out site inspections at regular intervals in accordance with the performance standards, and finally on successful completion of the project, a final certificate is issued.

**IN: A certificate of completion?**

15 BI03: We, an approved inspector issues- it's called a final certificate, whereas a certificate of completion is normally local authority, it's the same thing.

**IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006? Did you receive any training with regard to the new technical requirements of the Part L2A amendments?**

20 BI03: Obviously we were notified of the changes directly from the Office of the Deputy Prime Minister, which is now Communities and Local Government. From that stage, they provided us with the transitional arrangements with regard to projects that were actually on-going and about to come online as well as about to complete. Training was actually provided to the office directly from the RICS, as well as in house training from our own experts. We had an environmental services arm, which also were familiar with the changes and obviously the draft changes were sent to most of the building control organisations at a very early stage. And these were actually reviewed by senior staff members and various experts within the office and within our company. And then the CPD was actually spread within our company to notify all of the surveyors within the company of the changes.

30 **IN: What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?**

BI03: Well, for building control it's going to be relatively wide, for obvious reasons. But having said that, we are all still learning. And the Part L documents in particular are more complex now, certainly more complex than they have been in the past with the earlier versions and the editions. But in short, the answer to your question is actually it relatively wide and growing all the time.

35 **IN: So do you know how the NCM actually works, or are you familiar with the output and how that feeds back?**

BI03: I must admit it more the output, but we have to go slightly deeper than just the output. We have to understand how the output works with regard to compliance with Part L and Schedule 1 of the building regulations. So it has to go slightly deeper than just, sort of surface, we have to understand the workings behind it and the relevancy of demonstrating compliance towards the end of the project, otherwise we wouldn't be able to issue a final certificate.

**IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance?**

BI03: If the procedures are followed correctly and are checked correctly, I think they are quite effective in a lot of areas. But it is reliant on those procedures being followed and being checked correctly.

45 **IN: And, generally, the use of simulation tools to produce this output, how effective do you think that is?**

BI03: There is an issue with simulation programs, especially computer programs, because they are based on certain assumptions. But the physicality of those assumptions are checked with regard to inspections that are carried out after the simulation programs are actually taken and obviously you need to understand the background of the simulation. If you actually get a certain value within one of the simulations that just does not look right, there's for instance a U-Value of a particular wall, if it's way lower than it actually should be than just due to the construction- you've got to know the construction make up and if that actual U-Value that they're claiming that is achievable, is actually achievable. So you do have to have the background.

**IN: At which stage of the design process does your involvement usually begin?**

BI03: In short, the answer to that question is early as possible. The earlier we can actually come in, especially

55 with Part L being so new, to a very wide range of companies that are actually doing building at the moment- I mean Part L was actually sent through from the Communities and Local Government to building control bodies quite effectively, but then that information is going to get passed onto those who are doing the construction – and that's usually by consultants. So everybody was actually on a very steep learning curve. So we like to get involved as early as possible in projects, so that we can provide our input-making sure that we  
60 all can understand what we are actually trying to achieve with regard to compliance.

**IN: Roughly, at which RIBA stage?**

BI03: I have been involved in projects at the A and B Stage and in some cases, as early as feasibility.

**IN: And you prefer your involvement to come as early as possible?**

BI03: I think for a safe handover of a project, I think it's essential. The earlier the better with building control  
65 bodies. I know other building control bodies like to come in at certain stages. With Part L we thought because there was such a danger of things going horribly wrong and having a very high economic effect -especially on the client-the earlier the better.

**IN: Please describe the impact of your involvement on the development of projects.**

BI03: A lot of the projects I've been involved in, it's actually been one of surprise because they haven't realised  
70 Part L in particular has actually had such a major impact on their project, especially financially. There are a lot of things that they actually haven't considered although a lot of the consultants have actually aware that the SBEM calculation is now required and BERs and TERs ...etc. But now I don't think that we're getting so much surprise with everyone starting to get used to the idea. But Part L is actually once again under review soon and we're going to get a new one I believe in 2010. So I think they will be some more surprises in store.

75 **IN: So when you actually get involved do you provide design guidance, do you steer the design of the building to comply?**

BI03: We try not to steer, I mean what we try to do is fully inform the client and the consultant involved in the project of the requirements of Part L, and of course in the end compliance with the regulations. We're obviously not allowed to get involved in design and we don't get involved with the design, but we need to  
80 fully inform them of what building regulations are going to have an impact on their design and of course that includes Part L.

**IN: Who is your usual point of contact on projects? (architect, contractor, client....etc)**

BI03: It differs from project to project. Sometimes it's client-direct. With regard to commercial properties, especially new-build commercial properties which is what we're talking about, it would be the project  
85 manager, the client themselves or possibly the consultant that's actually been employed to actually do the consultancy on various stages. So if it's on Part L, we would actually contact the consultant concerned.

**IN: Do you view this to be the ideal person to interface with?**

BI03: Well I think the ideal person to interface with would normally be the consultant themselves. I mean, they are the consultant, they are the members of the design team who are actually meant to know what they are  
90 doing and they can understand. When you're actually taking to various members of the project team such as the client or the project manager or even the architect in some cases, they have a limited knowledge of Part L – and we are talking about Part L specifically- so therefore obviously the consultant is the most capable but they are not often brought in at an early stage.

**IN: And by consultant do you mean the architect?**

BI03: M & E consultant, mainly. So it's usually the M&E consultant usually on an M&E project dealing with Part L issues. Although having said that, I will qualify that the architect will have a lot more design input with regard to the building envelope. So it's a bit of a team effort.

**IN: Are the MEP people responsible for the Part L2A compliance simulation/calculation work?**

BI03: Normally, yes they are.

100 **IN: Which calculation tools/ methods are most frequently used to carry out this work?**

BI03: At the moment it's mainly been SBEM.

**IN: Have other tools been used?**

BI03: Sometimes SAP 2005 is used, mostly residential, but they have actually used it for small (non) domestic – but SBEM is mainly the one that they have used.

105 **IN: With regard to Part L2A compliance, what kind of information do you require to be submitted?**

BI03: Well initially what we would actually require is that the 5 criteria to be fulfilled. So therefore first of all we're actually looking at the CO<sub>2</sub> emissions of the building, which is actually the SBEM calculations, we would expect that the SBEM calculation to be passed through to us and that would be the relative data, input data, that's been used as well, not just the summary. Secondly we'll be looking at the air pressure test and the result

110 of the air pressure test on-site once the building is complete. We're also thirdly we're looking at making sure that the building envelope is compliant with the minimum standards with regard to U-Values and that that is also built on site. So therefore fourthly we're looking at regularly inspections to make sure that what has actually been passed to us with regard to data is actually been built on site.

**IN: And do you require information about HVAC systems to be submitted?**

115 BI03: Yes, we do. That would be included in the package. Also with the actual SAP calculation, sorry the SBEM calculation itself they would normally provide the specification for the HVAC systems and those efficiencies would be put into the calculation.

**IN: Do you require that they submitting the Part L2 A work be certified under either of the accreditation schemes?**

120 BI03: Yes, we would.

**IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route?**

BI03: To date, no. That seems to be the most accepted and most relevant method at the moment.

**IN: So nothing for overheating compliance demonstration?**

125 BI03: No, not normally. I mean most of the projects we get through do comply with Part L and usually use standard methods and any government approved method is the one most likely to be used by any consultant because it's the easiest way of showing compliance.

**IN: What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?**

130 BI03: With regard to the actual calculations themselves? What we would normally do is actually compare the SAP calculation and the building construction details with those required for a start, and obviously the efficiencies, then that would be carried on by the inspections making sure that what was actually calculated is being built on site, ensuring compliance. And then of course, finally making sure that that information is passed on to the client with regard to the management and maintenance of those systems.

135 **IN: Would there be anybody at the company, for instance, that goes through the calculations and makes sure things are correct?**

BI03: We would not normally check the actual, we would check the validity of the calculations, but we would not necessarily go through the calculations to re-check the consultants' workings. If that makes sense.

**IN: As long as they are certified or accredited?**

140 BI03: As long as they are certified or accredited, but we would go as far as we mentioned before to make sure that there are realistic values being used.

**IN: So you're checking the modelling assumptions, as such?**

BI03: Correct.

145 **IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**

BI03: Well for a start Part L, the requirements of Part L is actually legislation in itself, because it's actually been made law, it's no longer just a best practice as it would normally be under the old edition, there were certain minimums that were required to be met. So I think it's become a very important part now especially with the European Directive, Kyoto Agreement ... etc. So I think with regard to financial, or the possible financial implications, and the implication that Part L is not implemented within the project are far reaching and the client is very concerned obviously with the financial side that goes hand in hand obviously with the CO<sub>2</sub> emissions and reductions in the worldwide undertaking really to actually reduce those CO<sub>2</sub> emissions. So it's becoming a more important part.

150 **IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?**

BI03: I'm not sure too what you mean.

**IN: I mean for instance, the site inspections, building control officers looking at the documents – do you think these procedures are good enough to make sure that the end-product does actually comply?**

160 BI03: I think in theory, if they're done correctly and diligently, I think they are yes. At the moment, with today's standards – whether that's going to be enough in the future remains to be seen. But I think at the moment, with regard to the requirements and the over-riding requirement or targets with regard to Part L compliance, I think those are enough, if carried out correctly. I'll qualify that slightly too, because obviously you can't be on site the entire time so you are seeing a snapshot during the actual construction process, particularly with site inspections, so unfortunately, that snapshot will only give you an indication and there's

165 got to be due diligence carried out by the contractor on site to make sure he hasn't just shown you a piece that does comply and then trying to short-cut. I'm not saying that that goes on but with our type of work obviously a snapshot is not always enough.

**IN: What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance?**

170 BI03: I think one of the main issues I find is the fact that they still consider that it's actually easy to trade-off various things, in particular thermal elements. That is possible, but there are minimal standards that at the moment regardless we cannot drop below. It's also the difficulty that we stated with regard to the last question, the difficulty of actually only getting a snapshot during the process and actually hoping that due diligence is being carried out and best practice is being carried out with regard to construction on site. So there are I think shortfalls in the system, but if they are carried out by all consultants within the project, I think compliance can actually be met.

**IN: What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision and how would you recommend that these be dealt with?**

180 BI03: I think communication and education is one thing. It's got to be communicated correctly, the reason behind this is because there's a lot of scepticism out there with regard to CO<sub>2</sub> emissions and obviously global warming and the whole reason for Part L and implications of Part L on projects. Making it law has gone part-way through that because obviously everyone wants to comply with the law, but the checking systems have got to be tightened up I think and it's got to be realised that the system has got to have shortfalls no matter how tight they get. So I think that's the main thing, I think we just have to tight up what we've got and then move forward.

**IN: How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period)**

185 BI03: It's probably not up to me to actually dictate that, it would only be a personal opinion, but I think at the moment it's being reviewed enough, and there's got to be enough room from when it's being reviewed to implement to provide some sort of effective implementation and then move forward. I think 4 years is achievable but I know time is moving on and what they're trying to do is reach a target, I believe 2050, with CO<sub>2</sub> emissions. And with that timeframe in mind, although it'll be I think possibly unrealistic, the process has got to continue to evolve, it can't happen overnight, but it can't actually wait to the last minute either.

**IN: So you think the 4 years are currently achievable?**

195 BI03: I think they're achievable in actually providing changes to Part L, whether they're going to be effective in the final product remains to be seen,

**IN: You mentioned a standstill period, how long do you think that should be for effective implementation?**

200 BI03: Unfortunately, time is against us. We haven't got that luxury. I think we have to implement it as quickly as possible and as realistically as possible. At the moment 4 years seems to be providing enough information and the correct amount of time but we are always getting complaints about how often they're approving documents and also the guidance and any legislation is progressing, but times change, construction methods change, ideals change and targets change and we've just got to keep up with that to get an end result. We're obviously heading towards a long term target rather than just a short one.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

205 BI03: There's always room for improvement, but whether that improvement is actually going to be well received is a difficult question to answer. I think, as I said before, we are actually dictated by timeframes, and we may not have that time to actually make the implementation, the changes we need to make. In fact we may have now possibly run out of time. Especially with the construction industry, as I believe that it actually does provide 50% of overall CO<sub>2</sub> emissions, so that is quite high, and I think it's rushing to get to the end product as quickly as we can. As for improving the process, I think that that's for others to decide.

## B Interview 04 Transcript

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI04: They're mainly in the commercial sector. Ranging from hospitals, office blocks, shops, retail, conversions. And obviously in this current climate we're looking into residential as well.

**IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

- 5 We're approved inspectors, which means we check submissions under building regulations and any associated legislation, i.e. British standards, CIBSE Guides, stuff like that to make sure it complies with the building regulations.

**IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006? (increase in workload, costs...etc)**

- 10 BI04: I've only been in this job 12 months here so, that's pretty much standard of what's happening. But there's been an awful lot of background research to find out how we can comply or how we can interpret the regulations. And we've got some what I call 'Noddy' guys to help us through because the legislation is written in such a poor way.

**IN: Did you receive any training with regard to the new technical requirements of the Part L2A amendments?**

- 15 BI04: I personally didn't, no.

**IN: So your basic source of information would have been the research guys?**

They would, yes and going to CPD events to understand what the legislation is meant to do. And they would be carried out by CIBSE or my associates.

- 20 **IN: What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?**

BI04: I personally tend not to get involved with the minutia detailing, because our role is to check what people have submitted to us. So as long as it's a bone fide software system or a method of compliance which has been agreed by the government or the board of the BRE, that's how we do it.

- 25 **IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance? (expand to simulation tools)**

BI04: I think in principle it's a great idea because you start off with a, you're checking against a notional building, going to what you should achieve and then you have to do it all again at the end. It's trusting the end report which is the problem of knowing if people have changed any of their systems, have they changed the boilers, ratings, have they changed thermal elements which means it might not come out as good.

- 30 **IN: So it's a clear system for you?**

BI04: It's a clear system, but I think you can ride a bus through it.

**IN: At which stage of the design process does your involvement usually begin?**

- 35 BI04: It would be after the plans have been produced to check them. So at a very early stage. But most probably you've got an M & E consultant on board and there's not many people who come to ask which way or what method we would like them to use, which would be more cost-effective.

**IN: So you would prefer that your involvement be early on then?**

BI04: Yes, like everything. To be part of the team.

**IN: With regard to the RIBA stages?**

- 40 BI04: We definitely need to be in at, by C and D.

**IN: Please describe the impact of your involvement on the development of projects.**

- 45 BI04: I think most people appreciate that we're there, because the legislation is so complicated in other fields not just Part L. We seem to be the fountain of all knowledge, not masters of anything really. But we can guide people and tell them where to look and which is the best method of doing it and making sure that one lot of legislation does not muck up another lot of legislation. Because there's no use in putting up a fancy ventilation system if it can't fit my fire protection for life safety.

**IN: So you orchestrate the different legislative requirements?**

BI04: We tell the design team how to look into it yes, because a lot of the thermal has never killed anybody, but fire has.

- 50 **IN: Who is your usual point of contact on projects? (architect, contractor, client....etc)**

BI04: Architect or project manager.

**IN: Do you view this to be the ideal person to interface with?**

BI04: We find that the, we only normally send it to one person of contact who is in charge of the design team because it's then up to him to circulate it.

- 55 **IN: (If not) who would you prefer, and why?**  
 BI04: Yes in the size of the projects that we're dealing with. Because the teams are just so large and if someone what we agree could affect someone else's work, so again to keep the co-ordinated approach going you know you just can't put a hole in the floor if we need to put something through or a new window design which might affect planning permission or whatever so, one pint of contact.
- 60 **IN: Are they the person responsible for the Part L2A compliance simulation/calculation work?**  
 BI04: The architect would be, well the architect would let it out to an M&E consultant and the M&E would send us the information.  
**IN: So the architect would overview the process, but not necessarily do it?**  
 BI04: Yes
- 65 **IN: Which calculation tools/ methods are most frequently used to carry out this work?**  
 BI04: Only the ones I know here is Hevacomp. But obviously if there was one we didn't recognise we'd have to go and do some research and make sure that it was in the back of the documents that it was acceptable.  
**IN: Do you remember any of the names of the other software?**  
 BI04: No
- 70 **IN: With regard to Part L2A compliance, what kind of information do you require to be submitted? (e.g. modelling assumptions, HVAC systems..etc.)**  
 BI04: Normally it would be either the data input sheets, I'm not interested in reams of calculations because garbage in, garbage out. So normally it would be either the data input sheets, what's in the U-Values, what they're looking for, what's the efficiency ratings then the BER and the TER.
- 75 **IN: Do you require that they submitting the Part L2A work be certified under either of the accreditation schemes?**  
 BI04: I don't think we've received any which are not really. As long as they are using the right software components and we're happy that they're following the right procedures, then who are we to say that they are not competent? I don't believe that there's an association yet ready who is licensed or certified.
- 80 **IN: There's the Low Carbon Consultant Scheme, the CIBSE one and the BRE Competent Person Scheme.**  
 BI04: There's so many perceived experts in the field, as long as they're not abusing their data which is what we would look at. If we weren't happy with it, we'd find someone who is certified and get it checked out.  
**IN: So you would trust your own personal judgement in gauging if they are competent?**  
 BI04: Yes that's right.
- 85 **IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route? (e.g. for overheating)**  
 BI04: No  
**IN: What measures do you take to ensure the validity of Part L compliance calculation/simulation results?**  
 BI04: We're in the fortunate position that we're part of an M&E consultancy, so we would wander downstairs to see one of our professional client's contacts, colleagues shall we say, and say 'is this guy having a laugh?'. The trouble is that you've got to start to believe people, it's no good going in with this idea that he's out to get me, but if he does try it, we know what we look for. If it's European material then we'd ask for some additional information because it's not got a BRE certificate or a British Standard, you know it could be a DIMS or it could be whatever because lots of European material coming in now to start the envelope off, because the envelope is quite an important part of it, but the technicalities of systems is way outside our comfort zone, so that's down to experts.
- 95 **IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**  
 BI04: When we give advice at the beginning, we will go through the points that are politically sensitive and health and safety-wise first. So the normal order would be Part B, Part E, Part L and Part M.
- 100 **IN: So it's not very high up?**  
 BI04: As I said before, it doesn't kill anybody. I think the mindset is changing and it's a cultural change which needs to happen but until the government takes their own buildings seriously, why should we in the private enterprise?
- 105 **IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?**  
 BI04: Because there's no statutory inspections required, which is if we're going to take this seriously we've got to start to put in statutory inspections.  
**IN: At specific phases?**



- 110 BI04: Yes, that we sign off that the boiler is what it says on the tin, is actually the rating that they've put down, but you could do that on the self-certification. I think the big problem is that everyone wants to go down the self certification route, outside the control of building control. But therefore then it would just be people approving their own stuff if you're not careful. We need to do that, we do it ourselves, we come up with check sheets.
- 115 **IN: Here at the company?**  
 BI04: No we ask the client to do it and the contractors to say that under the critical details especially under airtightness which does affect (energy) as well, that that is sorted out and inspected by either us or the person on site.
- IN: But that's not an industry standard, that's something you've adopted here.**
- 120 BI04: That's right. We need the industry to come on board with us really.
- IN: What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance?**  
 BI04: Consequential improvements.
- IN: That's not new build, it's existing.**
- 125 BI04: New build there's no real issues in my opinion. We've got the legislation, they've got to comply. I think it's like anything now, they understand that it's got to be done. There was a lot of to-ing and fro-ing because there wasn't much materials around, the guides, especially building materials. And the problem was they kept changing the regulations so quick that manufacturers couldn't keep up. I still think they got the boilers wrong because they don't burn high enough. (The boilers) are not built for domestic situations. When you've
- 130 got proper plant, you can control it, because it needs controlling and then you can put all the BMSs in and it could be fantastic, but there's not that level put into the existing. So new is not a problem, or shouldn't be.
- IN: What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision? (i.e.- structural changes to the system, changes to the roles and responsibilities of key players...etc) and how would you recommend that these be dealt with? You mentioned the check sheets.**
- 135 BI04: If there's something to make our lives easier, we've got to sign it off. Unless we get training up, it's very awkward for us to walk into a plant room and say yes they've got all the right equipment, so there does need to be someone possibly looking into, to sign up what they're saying is going in. And then we can collect a certificate like we do with the fire certificate to say that that's a bone fide piece of the plant that's been done. That might have happened and I don't know about it in the (O&M) manuals, but I don't know if it does. And
- 140 the continuing control, I think this is the other thing, we can have fantastically efficient plant, but no one understands how to run it when the builders have finished with it, what happens then? When it's not being serviced, it's not being maintained and people don't understand the systems. So there's a huge learning curve there. It's the afterlife really. The building will comply from day one, day two we've got not control over it. And that's the system.
- 145 **IN: So putting in a system that will ensure that a building will comply throughout its lifetime?**  
 BI04: Yes, the supermarkets are really good at this because they've got so many stores they can't afford to waste energy. I know for a fact that Tesco monitor all their, remotely all their freezers in all stores and they know remotely which is going wrong and the plant is going wrong and everything, because they can't afford not to. But a lot of the landlords are interested. They're only interested in rent. So it's continuing control, but
- 150 how we do that. It could be done on meterage, I expect because the amount of energy could go to a carbon tax. We're supposed to have separate metering already for high usage, so the next step is that your energy use is linked to a carbon index, which is then another tax.
- IN: How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period)**
- 155 BI04: I think they've settled down now, because I think it's going to be 2010, 2013, 2016 so it's every 3 or four years, that's adequate. The main problem is that we can't keep pushing the fabric, because the fabric will squeal, it's going to be unbuildable, so I think that's near its limit. Except for windows, we can do some fancy stuff there, but other than that it'll just be smarter systems. So it's allowing the manufacturing industry the time to do the testing and the research.
- 160 **IN: So the 3-4 years is enough?**  
 BI04: Yes, it should be
- IN: So how long should the standstill period be?**  
 BI04: Well most regulations now are circulated 6 months before they come into operation, that's fine.
- IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

- 165 BI04: I think it needs to be simplified for people to understand it. I think they made it very complicated and as soon as it gets too complicated, people turn off. But I also think they need to put in some measures that will give some tax breaks as well. If you have the best building, if you got an A or a B rated building you're helping the environment so you should therefore be congratulated.

## B Interview 05 Transcript

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI05: We deal with everything really from small shops, very small commercial buildings through to new build office provision. We are discussing a couple principally I would say 15 to 20 storeys. We've got a couple of very large buildings that we're talking about, they're very, very early stages and to be honest we are unlikely to win the contract to deal with them I think. Anyway, that's a commercial thing.

Beyond that care homes figure quite highly, of various types, as do small scale educational buildings. We're actually partnered with a couple of practices who principally do a lot of educational work. So, although they don't work in Croydon so much, we're dealing with small scale schools buildings elsewhere relatively regularly.

10 **IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

BI05: It really depends on the individual project. The lower the scale of development, the lower of the value of the work shall we say, the higher the reliance on us to guide where the thing is going. That's either because there is no design team, or the design team are not, don't have the specialist knowledge, shall we say.

As you go up the ladder, it really depends entirely on the development. The bigger the building, the more specialists are involved in it, the – generally speaking- more knowledgeable they are. In that case our involvement is really guiding, making sure that things are not missed, things don't drop between the cracks. We would aim, principally, in a large-ish new build to ensure that the Part L analysis is done very early, preferably pre-planning. That way, there are no surprises later on in the development of it and things that we may have looked to have changed then don't impact on them going back to get planning permission again because things don't work.

So we aim to get that Part L analysis done at round about or probably even before Stage D. We use it to set a set of performance targets for the building which we can then come back to later on with the construction data, so that we know that it's going to comply, we just need to get the U-Values and the air-tightness, the lighting-the actual components to fit in with that performance spec that we've got them to generate at an early stage.

25 **IN: So your involvement is to guide the design team and that will vary according to how early or late your involvement is and the scale of the project?**

BI05: Yes that's principally the route we aim to take.

**IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006? (increase in workload, costs...etc)**

30 BI05: I don't think there were significant changes made, organisationally. L1 and the performance-based approach to some extent has been around the mid-nineties with its introduction for new build residential, mainly it was an extension of that to the non-residential, the non-domestic sector, if you like. So, we found it was just a question of getting used to the new approved document, getting used to the new guidance. The actual document wasn't any different it was still reasonable provision with regard to energy performance, so the requirement wasn't, it was just the approach that was taken. So it was just a question of getting used to what was in the guidance, getting used to the calculation tool and how it worked, getting our head around how the market was dealing with it or not dealing with it, which was probably more the case.

**IN: Was there an increase in workload that you noticed?**

40 BI05: There was an increase in workload over that period anyway because it was a very busy time in construction. So whether or not there was anything specific that came out of Part L changes, I couldn't say. To some extent it's made it easier for us because we don't have to go down the road with all kinds of target U-Values, negotiation of what we are going to accept and what we are not going to accept because we now have a tool, as I said before, that we can use to generate this performance specification for the building before it even goes in for planning permission and then later on we can come back and deal with the technical issues. I don't think that it actually has created an increase in workload. Obviously, the learning curve at the beginning can make things a little tricky, it can keep involvement out a little bit because people have to learn. Now that we have done that, I don't think there are any significant issues there.

**IN: Did you receive any training with regard to the new technical requirements of the Part L2A amendments? Please describe and please describe alternative source of information.**

50 BI05: Not with regard to the requirements of the new Part L. Yes, everybody attended the introductory seminars. Yes, we've done some stuff that's a little bit beyond that. The end of the day, I would hope that my team are professional building control surveyors. The approved document is exactly that, it's an approved document, and the view in training and development that we take here is that we don't somebody else's view of what the approved document says to be implemented in Croydon. We want our people to be able to read

55 the approved document, to be able to work out what it is saying, to be able to follow their way through it and not repeat something which they may have learned elsewhere parrot-fashion which may be incorrect. So we would hope that they would be equipped with the skills set to do that. It's then better for us to direct our training in terms of technical matters, which is what we should be doing. We shouldn't be sending people off to learning what is says in a book that they should read.

60 **IN: What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?**

BI05: I could have grown with that personally, I wrote my dissertation when they introduced SAP originally, based on whether or not it was going to initially result in improvements in energy efficiency in the residential market. It also dealt with embodied energy and whether that would be a better approach. So, my history with these things goes back to the mid-nineties, anyway. SAP and the domestic side has changed and evolved over that time.

The way I view the NCM with regard to L2 is another evolution of that, it's a similar approach. You model your building, you compare your building to something notional. It's a question of just getting used to the software, if you like.

70 **IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance?**

BI05: It's not a yes or no answer strictly. Compliance, the building regulations are performance-based, anyway. The building regulations simply say, the law, the legal bit says that you have to make reasonable provision in terms of energy performance. It's for the building control body, whether that's local authority or an approved inspector to some extent decide what reasonable provision is.

75 There is a second strand to it from the European side that says your new building must have at least the level of performance of a notional, which skews things slightly. As a tool, there are 2 approaches that can be taken. One I think is very prescriptive, that's the approach we used to take that says you must have this U-Value for this, you must have that value for air-tightness and your windows must achieve this in your air-con or something else. But the problem with that is it's inflexible, it doesn't deal with novel approaches, it doesn't deal with things that are out on the fringe, it doesn't deal with people's ideas and desires and it doesn't respond very well. The use of the NCM should be able to do all of these things.

**IN: So you think it provides that degree of flexibility?**

BI05: I think flexibility is there, yes, because at the end of the day you plug in your novel design, which uses whatever materials you are going to use or you model your novel building which is made entirely of papier mache, for example, and you have an idea of whether or not that is going to comply with the building regulations. You have a set of performance criteria, You can play with the performance of you air-con or your lighting or your fabric and air-tightness, whichever of the parameters you wish to play around with within the permissible bounds and it will tell you whether or not you can reasonably expect it to work. It will also tell you whether you need ridiculously high U-Values out of something.

90 So as a design tool, which is what it should be used as, yes I think it does have the flexibility. Clearly there will be limitations, clearly there will be novel approaches that develop that someone needs to work out a means of plugging them in, a means of getting the NCM itself to accept them. Residentially, one of those was something like community heating. It had to be changed to accommodate that. And the same kind of thing, I don't know. I don't know whether the NCM for non-residential, whether SBEM deals with that. Potentially, someone can come along and say I'm going to use community heating with this office block. It may not accept that, it may need weakening to deal with that as it becomes a growing trend. But it's possible to do those things. Somebody out there is responsible for making sure that the NCM is capable of doing those things. Yes, I do think it has possibilities. Obviously, people may place a little bit too much reliance on some of the performance figures that come out of the other end. They may go to their client and say it's going to cost you this because it uses that much electricity and that much gas and you need this much of something else, it's not an air-con design tool, it doesn't design your services for you, people sometimes confuse that, but that's not what it's there for. The short answer is yes.

**IN: At which stage of the design process does your involvement usually begin? You mentioned that you prefer it at Stage D.**

105 BI05: We prefer it earlier than that. We don't want to get involved in the conceptualisation of something, unless.....no we just don't. We have no business being involved in the conceptualisation of something, but once that conceptualisation starts to become a firm notionalisation of something that is going to be submitted for planning permission, that's where we would like to be in.

**IN: Do you think involvement at this stage is effective in ensuring Part L2A compliance? So your**

110 **preference would be earlier than Stage D?**

BI05: Absolutely. It gets a little bit woolly prior to that sometimes. I wouldn't commit to a stage early on in the design development. Again it depends on the development. It becomes difficult because it's almost like asking the designer, developer, whoever is driving the thing to commit to the building control body at such an early stage in the generation of the development. Yes, we would love that to be the case, but unfortunately further  
 115 down the road the development gets sent out for tender and whoever ends up building it may have their own preferences. So work can be a little abortive, somebody can perhaps come to us under those circumstances after agreeing it all with an AI and we say 'actually we don't agree with that'. So, actually it can be very woolly. Our involvement at such an early stage would also necessarily be quite woolly. We go to design meetings and people say 'what is it you're looking for here and what can I get away with?' is the standard  
 120 term. Our response would be 'you can get away with anything you like as long as we can prove it at the end of the day'. And it's a question of talking through these plans, trying to guide people through doing a very early Part L assessment, trying to educate people through that 'yes, I know you don't have a services guy on board yet, but it's money well spent to engage somebody to do this early stage SBEM, and really get that set of performance criteria set in right at the beginning'.

125 **IN: Please describe the impact of your involvement on the development of projects.**

BI05: It does vary, I mean this is the approach we like to take (see previous), this is what makes us comfortable. Often we'll get one that comes in and says, no it's ok we've seen (a hand), fine lovely.

**IN: Who is your usual point of contact on projects? (architect, contractor, client....etc)**

BI05: It varies throughout the project itself. Usually at an early stage it will be the architect. The smaller the  
 130 development- people tend to focus on nice big office buildings like hospitals or a big school when they're discussing these things, there's a whole other world out there, we have a post office which is probably not much bigger than 3 of these rooms, it's still a new building and it's still covered by Part L2. Clearly it would be very different on that one than it would be than on 20 storeys that was going to be built over there. Our involvement would be with the designer, who would more than likely be a local guy who doesn't have any  
 135 specific specialism anywhere. We would deal with only him and perhaps his client throughout the duration of the job until it comes to be built and we deal with the builder, that's standard building control stuff. On a large scale development, it would usually start at an early stage with the architect. We may be called in to simply discuss things, there's by no means a guarantee that we'll continue with it. Quite often a very early discussion is tantamount to an interview, and they will have us, they will have AIs and they'll want to see the response  
 140 that people take, they want to see the approach that they're going to take to this development. But for us, A: it's an opportunity to be engaged and B, as long as we get a decent message across, it doesn't matter.

**IN: Do you view this to be the ideal person to interface with, who would you prefer, and why?**

BI05: We'd much rather prefer to be involved with whoever is going to engage the building control body at the end of the day, but that's a commercial thing for us.

145 **IN: So the architect's involvement can stage at a certain stage?**

BI05: Yes, absolutely. They can get planning permission and they're never involved with it again, potentially. Quite often the way developments seem to be undertaken- the larger scale development- is the planning permission will be gained and rather than one person carrying the risk, rather than the developer carrying the risk and providing the money, the development itself will become a business, if you like. It's quite often a  
 150 Limited Liability Partnership or something like that and things change completely at that point because people may be involved or may not be involved. With the developers over here, nobody is central to the whole thing, generally speaking with the architect who guides where it is going and tries to pull everything together into one box, if you like, quite often the whole development of the scheme, that's who we would prefer to be dealing with.

155 **IN: Are they the person responsible for the Part L2A compliance simulation/calculation work?**

BI05: No they (the architects) rarely are, that will be the services people. Almost invariably, the services people. The architect will perhaps download a copy of SBEM, they may install it and run it once, and then run away. Surveyors are the same. It doesn't matter if it's 50 storeys or a small building in the grounds of a school, this thing happens and it's very rare that the designer progresses the SBEM modelling, if you like.

160 **IN: If the architect were the person co-ordinating, they would bring you the document rather than the person who has done it?**

BI05: Generally speaking, yes. Of course when I say 'architect', it's generic.

**IN: Which calculation tools/ methods are most frequently used to carry out this work?**

BI05: The things we actually get involved with checking the output document, the compliance checklist, what

165 have you actually done to model this- would be the smaller scale work because that's where we have most problems. It's where the consultants involved are least experienced. Almost invariably that will come in on an SBEM output and quite often we will get the whole project and look in on what's gone into this thing. The further up the line you go, the less we get involved with the nuts and bolts. We will discuss assumptions, we will discuss approaches, we may not actually get a compliance checklist because we would hope to be sitting  
 170 in a room at a workshop or something just running through what is it you've done, what's come out of it. I'll be honest with you, I can't remember offhand the names of the packages that were used. We don't get involved with them too deeply. I guess what I'm trying to say is, you get a feeling for how much you trust the people to be able to choose what they are using. Do I feel comfortable with that, and the more comfortable you feel, the less you want to or need to get involved with the nuts and bolts of what they've actually put into their design tool. We'd agree the parameters, we'd agree the base assumptions. We would get at the end of the day an issue of a compliance checklist, a set of U-Values, a set of performance criteria. We would focus more heavily, rather than look at whether or not they've modelled that correctly. We would focus more heavily later on whether the products that are incorporated into the building are going to deliver what they're supposed to. We think that's more important, that's where it goes wrong. For big buildings, that's where it goes wrong, small buildings, people don't know how to use the design tool and yes we get involved with that, but that will tend to be SBEM.

**IN: With regard to Part L2A compliance, what kind of information do you require to be submitted?**

185 BI05: It changes through the development of the scheme, really. As I said, a small scheme, you'd get the whole package, the U-Values, the design, the performance of the services, the proposed air-tightness values, the overheating or whatever. You would get all of that, one package, early on. You would check it quite thoroughly, you'd hopefully approve it and then you'd deal with it on site. You're getting things like manufacturers data for the split units or what have you, the lighting information, the performance information for basically every part of the building that impacts on the L2 calculation.

190 It doesn't have to be complex. We've got one on a small school building or this post office, it's the SBEM calculation. It's the U-Value calcs from the block work people, the insulation people, it's packaged air conditioning. Glazing is usually the biggest problem. So it can be a wide-ranging pile of information, but it doesn't have to be overly complex. People make it so. It's quite simple to package this up into one document and fire it off into a PDF

195 With a larger building, clearly the complexity is exponentially increased, but it's not done in one go. As I said before, we try to engineer the early stage formulation of a set of performance criteria, so at that point, we're not even considering the construction of the building, we're not considering what components are going in to set it up. The designers and what have you will may be have some notion of what they want to do, but that may or may not change. So we'd get that in place whereby we can hopefully give some kind of conditional approval. We break these things down into packages and we would give a conditional approval on the conceptual Part L design, which is what we're talking about realistically.

**IN: The 'as designed'?**

200 BI05: Yes, it's the conceptual side of things. It's that package of performance criteria. You don't want to know what the U-Value of the wall panel is compared to the glazed bit and the floor insulation. We're not interested at that stage. That's going to be done later on. So we'd move on through the development of the scheme and the design of the scheme and then it would be back to the table to say ok this is our performance criteria, this is what we're going to do. We can't actually meet that U-Value, so we're tweaking this elsewhere. So the complexity and the volume is spread throughout the design and quite often the construction of the building. An example I've got which is actually residential, but it illustrates the same approach, it's a very, very large block of flats which we adopted exactly this approach but obviously with the SAP analysis, that changed from  
 210 a CHP proposal, which is what it was modelled on with one form of cladding, which was the thought process early on, that changed- quite dramatically- to community heating, packaged, imported, pre-fabricated panels. But because we've taken the approach we've taken, we've looked at that set of performance criteria, such a significant change doesn't impact heavily on us. It impacts heavily on the poor guy who's done I think it's a 180 SAP calculations, because he needs to go back and re-do them. Obviously if it was an office building, may  
 215 be fundamentally changing the approach to how you're going to heat it may not be quite so difficult because you're not dealing with 180 separate calculations, you're dealing with one building, one model, not 180 of them.

So although it is a huge amount of information, it's like breaking things down into stages, so the impact and the workload and the sheer volume of it doesn't really become overwhelming. And it's a logical approach.

220 You can see where things are not quite fitting. You're not trying to deal with whether or not the cladding system is going to achieve whatever U-Value or whether it's a cladding system, or rain screen or curtain wall or how you're going to even define it as well as you're going to notice that they have a ridiculous air-tightness figure and that's why it complies and in addition to that what about the extra 10% that planning require for on-site LZC or something? You're not trying to get your head around all of this at one go, you're breaking it into packages and dealing with it one piece at a time.

**IN: Do you require that they submitting the Part L2A work be certified under either of the accreditation schemes?**

BI05: No. I don't think there's anything anywhere that requires that the person producing the L2 analysis to be qualified.

230 **IN: How do you gauge their competency?**

BI05: Firstly, if you're capable of using your tool, which you've selected, whether if its SBEM or something else or whether it's a spreadsheet that you've written yourself, which you'd obviously have to get checked by the BRE. We used to get that prior to the requirement for the software to be approved people producing things using Excel, I've done it myself. Obviously it's a bit more difficult after that, now its 'is it approved', 'yes', 'good, do you know how to use it?' And it's relatively evident at an early stage whether or not somebody knows how to use it.

**IN: So it's relying on your personal judgement?**

BI05: Absolutely, and it must be.

240 **IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route? (e.g. for overheating)**

BI05: Overheating checks are very fuzzy. We have consultants that don't even know that SBEM does an overheating check or where to find it. Admittedly, it's buried in the depths of the thing and it's difficult to locate. It would be difficult for us to justify accepting an output that doesn't come from the NCM or an approved package. However, saying that we've not been presented with that. We've not had somebody come along and say here's my finger in the air assessment of whether or not....If somebody wanted to go through various codes and what have you and do a full rundown of whether this thing is going to overheat in the summer, you'd have to live with that.

We're not the government, which means we're not in the business of saying you can do that, you can't do that, we're in the business of saying what have you done, let's have a look. I'm not comfortable, can you explain it to me. And it's unlikely.... in L2 overheating, generally speaking, doesn't present us with a problem on the larger buildings because they are all air conditioned. If someone were to decide that they wanted to use something like passive stack, for example in this place, if somebody decided that they wanted to use passive stack on the escape staircase and draw the air through the building that way and make use of the fact that it's often 20°C hotter on one side than it is on the other, then we'd be stuck. But then so would the NCM, because it wouldn't deal with it very well. At the moment, I think the notion of solar overheating isn't well dealt with, nobody deals with it with any great depth. I don't think we get over-excited too much, so as long as it doesn't say 'high', that's good enough for me. I think that will change in the future, I think the approach has been to introduce that now and its significance and the way it's modelled will evolve.

255 **IN: What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?**

BI05: That's the benefit of the approved packages, they tell you if they are.

**IN: You trust the output because the software has been tested?**

260 BI05: Yes, and you've got a significant central London M&E practice or an environmental consultancy- and I don't mean some guy down the road operating out of his garage. If you've got an established contact, you will know whether or not they're being a little fly. If they're going to manipulate the output, it's going to happen. The lower end of the scale, as I said, if we're worried or something's not quite working or there are some assumptions in here which are inconsistent, we would then request the project files-the electronic project files-we'd run it through SBEM here and actually have a look at what's going on.

270 **IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**

BI05: It's a misnomer that Part L isn't to do with health and safety. We were talking about solar overheating, that's very much a health and safety issue. I've been in here when its 94°F and its unbearable. That's a complete misnomer and people need to get their head around it.

The four main aspects of the regulations that we seek to get buttoned down are structure is one obvious one,

275 fire is the second, access is the third. It's fair to say that over the last five years to say the energy has become the fourth of those.

It's easier to talk about the larger scale developments because the phases it goes through, the development is much more pronounced because same things happen on the small- all developments goes through the same design and construction process. We will seek to, if we're negotiating or discussing a proposed office block  
280 over by the station there, which we are, we have one there that we're discussing at the moment, we find that there are a couple of things, we need to have a level of comfort ourselves, and traditionally specifically local authority building control has a poor reputation with the developer, because they expect us to day one thing one minute and something else later on. So to combat that, we develop an approach whereby, as I said before, we'll package the development up. We will deal with the conceptual design under structure, the conceptual  
285 fire design, the conceptual Part L package. Access tends to be a wee bit more less conceptual, if you like.

So for those four areas of the regulations, we're giving a conditional approval at a very early stage saying we're happy with this concept, subject to it being developed so on and so forth. We then go on and develop that concept into the performance package and we would usually be happy to conditionally approve that as well. So, the developer has something in his hand, if we go 'actually we don't like that anymore' or if the  
290 regulations change he can say 'look you've approved it, there it is' and we're kind of like, 'fine'.

Pretty much the nuts and bolts of the building, the drains, the staircases, the banisters can be dealt with as the thing progresses. There's a lot of discussion at the moment about reducing the use of building notices, that you can't use a building notice on a commercial building. The fact of the matter is that any significant commercial building follows the same process as the building notice anyway because you never get all of the information  
295 so that you can go 'Approved. Here is your approved plan, thank you very much' - it doesn't happen like that.

So we seek to establish those four main items early on, once they're in place- you have to have your Part L package in place early, your performance specs, it's a significant part of the building regs because it also influences F: Ventilation, you can't design that without having first done Part L. I think the whole thing is confused because the likes of the GLA and the planning authorities have involved themselves quite heavily in  
300 the energy efficiency side of things. Now we have national regulation for that, it's called the building regulations, and to my opinion, the GLA, the local planning authority should not be in the position of actually saying 'yes, we do have that, but we want something better'. Nationally the standard has been set, it is the Building Regulations and nationally, I think that the planning authorities should be told to back off. I think the planning inspectorate needs to be saying 'why have you put this energy efficiency condition on that's covered  
305 by the building regs elsewhere?'. And I think that that is confusing the whole thing because there is no consistency. There isn't consistent application of the GLA guidance, you get inconsistent application across authority boundaries and within authorities themselves. You end up bickering and arguing over the definition of what that 10% low and zero carbon is, but in fact there is a modification factor built into Part L2 anyway that encourages LZC, it doesn't require it but it encourages it. I think that's where the bigger issues lie. The fact that the developer isn't speaking to only us about it, they also have to speak to a planning officer it, who doesn't understand it and doesn't have any knowledge of it, but needs to tick that box on the planning application. I think that's a bigger issue in the profile of the building regs. Yes, you're quite right the historic thing was 'nobody's going to die of that' that is changing over the last five years, it has been changing quite rapidly.

315 **IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?**

BI05: I think it's relatively effective. I think it's important whoever the building control body is, they have somebody who, or they have people who at least have a relatively deep appreciation of what it says in the approved document and generate an approach to dealing with it. I think that may be part of the problem out  
320 there is that is not the case. Everybody wants to be involved with fire because that's 'sexy' - insulation is not, although it's becoming more so, which is why the planning authority is getting involved with it.

The approved document itself sets out an approach to ensuring compliance. It's a question of, the design is submitted, it has to be, there is no more elemental value approach, there has to be a design and it has to be supported by something.

325 **IN: So the procedures are there and if they're followed correctly that will ensure compliance?**

BI05: Absolutely.

**IN: What are the other main issues, if any, do you most frequently encounter with regard to Part L2A compliance?**

BI05: I think it's really the reliability of the information, that's the main one. Even manufacturers information



330 isn't always reliable. People don't always understand what it is they need to achieve, you get embroiled in  
bickering over the definition of 'high-usage personnel door' or 'display lighting', things like that. It's really  
those kind of areas and the lower level development that causes the issues. People like to talk about nice big  
office blocks and a big new school, that's probably less than 5% of the total development. Most of them are the  
post office a new school block, which is may be 2 classrooms and a corridor, these are the regular day to day  
335 pieces of development that as a local authority we usually end up with because it's not commercially viable for  
an AI to deal with them. These are the ones that fall outside of which, well the developer whether it's a school  
governing team or a guy building a little shop somewhere or a workshop or a garage whatever, he's not going  
to want to spend the money on air-tightness testing. So, these are the ones that we have to then get involved  
with. How are we going to make this work sensibly with an air-tightness figure of 15 assumed? How are we  
340 going to make these 2 classrooms- we've had a hell of trouble with one recently. Two classrooms and a  
corridor and it simply cannot be made to satisfy the overheating without air conditioning. It's the only way we  
found to make it work, with regard to solar overheating, because with regard to air-con, who is going to air  
condition 2 classrooms? It's just not sensible.

These are the things that we have more difficulties with. Procedurally, we're ok, we don't have any issues  
345 procedurally. We get the design, we check the assumptions, we look at the work on-site, if it differs we say it's  
ok it's not a problem, we can work with that as long as we tell the people that they're running a risk. At the  
end of the day we get the revised set of calcs with the 'as-built' air-tightness value and we sign it off. Or we  
don't get those things and we don't sign it off. Or it's horrendously bad and we have to deal with the  
enforcement side of the job. It's the lower level developments, when you don't have these.

350 **IN: What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision? (i.e.-  
structural changes to the system, changes to the roles and responsibilities of key players...etc) and how  
would you recommend that these be dealt with?**

BI05: I think, as I've said, there's not much wrong with the framework itself. I think some work needs to be  
done on where these things are going to be enforced and who by. It needs to be either the building control  
355 body or the planning authority. One or the other, not both. My personal opinion, is that it should be the  
building control body, planning can concentrate on policy matters, planning can concentrate on whether or  
not they're looking to generate a community heating system. It's the large and more global things, they  
shouldn't be concentrating on things that are covered by the regs on a specific development. So that needs to  
be sorted out. I think it badly needs to be sorted out.

360 Large scale building, I don't think that there are any significant issues with regard to Part L. It's now  
recognised that it's essential to do the analysis early on, we rarely have to say that now on a large building.  
Same on housing, most things from a block of flats upwards, which people now recognise the fact that they  
have to do this Part L assessment before they submit for planning permission.

**IN: So it's the smaller projects?**

365 BI05: Yes. Obviously, the NCM will need to continue developing, will need to continue evolving. It will need  
to deal with, there are countless things out there that it will need to deal with. Even down the road of are we  
considering moving away from energy efficiency, which is what we have traditionally dealt with, and is it  
now going to move into sustainability and environment. Which I guess naturally, it will have to. If it's going to  
do that, how are going to introduce rainwater harvesting into these models? Because they will need to accept  
370 the widening remit.

With regard to larger scale development, those are the kind of concerns that we can see, but it's the smaller  
developments, the little one-off things here and there that I'm not even 100% convinced that the NCM is the  
right tool for. I don't actually know where that needs to go, but the classroom I mentioned for example, we're  
asking people to get an SBEM analysis done for 2 classrooms and a corridor and they've got consultants who  
375 say it's going to cost them £8,000. The practice that are doing the design for this are saying 'sorry, go away' –  
they found somebody to do it for about £300, but it's wrong, and they don't actually know how to use SBEM at  
all. Even, apparently by the look of it, don't get the concept of what they're trying to achieve with the  
modelling. I'm not convinced that's a desirable situation and I'm not convinced that it's going to change.

Beyond that, far too much comes out of CLG which demonstrates a breadth of understanding of the sector. I  
380 guess that's what I'm just talking about. Far too much is done up there by consultants who have brief and  
actually they don't go far too much into the market yet, as you're doing yourself, to find out what is going on.  
There isn't specific knowledge. If you go to a number of the conferences or seminars or what have you, you'd  
be forgiven for thinking- I know it's not specifically down the avenue of energy efficiency, (that) building  
control deals with new houses, because that's where the lobby group is. So those are the people that have been

385 bending people at CLG's ear or the consultants that are doing the consultation process for them. So naturally, they think most of the market is new housing. And the poor guy building an extension doesn't really get a consideration. It's easy to come up with frameworks that deal with larger-scale developments, it's the smaller stuff that's the problem. You can't expect someone to spend £5,000-£8,000 on an SBEM tool analysis for 2 classrooms that you can't stop from overheating. It's difficult in that area.

390 **IN: How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period)**

BI05: I think 4 years, I don't have a problem with that. I don't subscribe to this 'the regulations change too often' - the regulations change, one would hope, when they need to. I think the building control industry has been its own worst enemy with regard to that because they've been running around saying 'it's too complicated, it's this, it's that'. These people have a job and their job is to know what it says in the approved documents and to guide somebody. Building control people want to be considered to be professional and want to be considered to be part of the team that is delivering this building, you can't then run around saying 'I need training on what it says in the approved document'. It is nonsense, people need to get over that. If the regs need to change, you read the approved documents, it might be complicated, but then you're a professional person. You want to have the same standing as an architect, a surveyor- they're all surveyors- a lawyer, start behaving like one.

I don't think it's necessarily Part L that's the problem here, I don't think it's regulations changing too often, as I said people don't like it, obviously but just get on with it. I think there are more significant changes that are going to happen, I think the building control body, whether or not it's an AI or a Local Authority needs to bear more responsibility for what they're saying or doing. If we have a design meeting and we agree an approach and it turns out to be to fail, then I should stand by what I've said. Now at the moment case law demonstrates that it doesn't matter what I agree, it's your fault because you've designed it and you built it. Unless some wilful form of negligence can be demonstrated, I can sit there and go 'whatever'. That needs to change.

I some ways the framework that supports it is no longer consistent with what people expect from the person who is- I was going to say enforcing the building regs, you don't really do that much anymore-that's one of the big problems we've had going back to the beginning with regard to freedom of information and criticism over 'you're local authority building control, you don't enforce Part L' - actually we do, everyday of the week, it's just we don't get to court, we deal with it before that, before it's necessary. It's 'soft enforcement', it's 'actually, that's not right. What is the level of performance of your window? Where is your specific low energy light fitting?' It's a failure if you actually have to go to court, because it's expensive and it doesn't achieve anything.

I think perhaps the publicity period needs to be longer. The current crop of Part L documents got released, I think it was something ridiculous like 6 weeks before they actually came into force and nobody actually knew. But if they need to be changed and corrected, change and correct it then say it's coming in, not it's coming in on Wednesday- people can't work with that. Particularly as the content was never accurately publicised and significant things did change. So you couldn't gear up. Professionally you could expect to be ready for that thing to come in and that wasn't possible because of the very, very short period of time and the fact that it changed. That can't happen again. They don't need to be secret.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

425 BI05: It's like most things, some of it works, some of it doesn't. If it works for some things, it doesn't work for other things. The biggest problem is perhaps the perception of the building control practitioners involved in it. Their client-the developer-doesn't need to know this. That's what society is coming around to saying 'we are no longer the building police, we want you to help us' and we need to be in a position where we can do that. There's nothing wrong with the approved document, substantially. There's nothing wrong with the approach, substantially. It needs to develop to cater for solar overheating, small developments, things that are changing, but there is no reason why it can't do that. Those things need to happen, but the framework and the approach, I don't see issues with.

## B Interview 06 Transcript

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI06-A: (Our company) will deal with about 2,000-2,500 projects in a year, ranging from a public health refurbishment, shop fit-out, offices refurbishment and fit-out. Projects ranging from £50,000 construction value up to...our largest scheme that we've got on the books is estimated at about £500 million construction value. So the full spectrum of projects.

**IN: Are most of them non-domestic or domestic?**

BI06-A: Up to a few years ago, pretty much 100% was non-domestic, then we went through-when they re-changed the license to allow us to do residential- we dealt with a number of mixed use and high-rise residential schemes. So we don't do anything in the domestic (kitchen extensions...etc), we'll do high-rise flats, but of course the majority of those projects are now on hold and not being built.

**IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

BI06-A: At (company name) building control, we would be involved normally Stage B, Stage C, RIBA Stage B or C concept stage. We would attend design team meetings, advise on methods of compliance and try to assist the project team in achieving cost certainty and obviously risk reduction, so an on-going compliance audit during the concept stage then during the planning stage we'll be reviewing drawings for actual checks ...etc. then carry out the site inspection and then at the end obviously be at the various commissioning inspections.

**IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006? (increase in workload, costs...etc)**

BI06-A: Unfortunately, fee/income didn't make any difference at all. I think some construction values went up, which in turn would change our fee. But our fees weren't increased due to the implementation of the new Part L. Every time that there's been a change in legislation, like a Part B or a Part L, there's an influx of projects where clients are trying to get projects fixed prior to implementation and I think the way that the government do the transitional period changes each time and they're obviously tightening up on that. Previously I think with Part B all we had to do was serve the initial notice to Local Authority, this is going back to 2002 so I might not be 100% right here, but I think it was serving the initial notice, we had to lodge the application, that then fixed the regulations. Part L, we had to serve the initial notice and issue a planning certificate or there was a meaningful start on site. That then forced a lot of architects to really apply pressure to get the designs to a position where the building regs approval, a planning certificate could be done. And there was an influx of work because people were bringing us in to get those planning certificates done.

**IN: Did you receive any training with regard to the new technical requirements of the Part L2A amendments? Please describe these methods and describe alternative source of information.**

BI06-A: Our staff, there was a number of technical seminars run by, I think, the Association of Building Engineers. The RICS carried out technical seminars. We ourselves provided a road show nationally to our clients. So every time there is a change in legislation, we always go out and carry out a number of technical seminars advising our clients on the changes and how to adapt the designs to take those into account.

**IN: So you trained your staff and were also involved in training industry?**

BI06-A: Yes.

**IN: What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?**

BI06-A: Mine, not so much, because I'm a business development director. But we've got a number of technical directors and managing surveyors.

BI06-B: We're constantly holding training sessions for our staff on all aspects of the regulations and Part L is one where we have refresher sessions on a regular period because there's a lot of information to take in. And we want to make sure that we give the clients the correct information because that's what they value in our service. So our technical directors have a comprehensive degree of knowledge. Andy Lowe is one of the experts-

BI06-A: He reviews the consultation papers when they come out and normally comments on those and then, as an example, last month he was presenting at the annual RICS conference and presented on Part L and also at EcoBuild in Earls Court.

**IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance?**

BI06-B: I think it's quite effective, but it's interpreting the information, making sure that the architects (not necessarily the people producing the calculation and methodology), that they understand what's required. That's the area which could do with more input as to getting the construction industry, generally, to get a better understanding of what's required under Part L and compliance with that. The methodology is quite

55 straight forward and once you've got the background as to where they've come from and how they've carried out the calculations...etc.

**IN: So it makes your job easier in a sense?**

BI06-B: Yes. What you've got to be careful with, is just to check if they've got the figures they're inputting tie up with what architects have stated in their drawings...etc and making sure that it is an approved  
60 methodology because sometimes they can cloud the issue a bit.

**IN: At which stage of the design process does your involvement usually begin? You mentioned your involvement begins at Stage C?**

BI06-A: Yes

**IN: Do you think involvement at this stage is effective in ensuring Part L2A compliance?**

65 BI06-A: Definitely.

GH: Yes, its stops or prevents a lot of abortive design.

BI06-A: Which in turn- you know, abortive design is a cost against the project. I think that there's two big differences that when it comes to new-build construction the application of Part L is far easier and (for) architects it's pretty straight forward, it's following the document and there's an element of interpretation, but  
70 then with the various software packages, SBEM and Tas and things like that, the M&E consultants are working with the architects and it's pretty straight forward. The grey area comes in when it's a refurbishment project and they've got things like consequential improvements, that then suddenly becomes the grey area. And there's always, they way the regulations are written in terms of the percentage of consequential improvement, how that can be applied and then there's the cost (the payback period) and then those sort of things are open  
75 to interpretation.

**IN: Please describe the impact of your involvement on the development of projects.**

BI06-B: Well the impact would be to steer the design team down the correct path or give them options on the design which they may not have considered. And that would add, possibly, cost saving benefits to the project or sometimes it will be an increase in cost which they haven't taken into account. So it's important that we are  
80 consulted at least Stage C would be the preferred period, because the design is still fluid and we can amend it without incurring too many difficulties.

**IN: Who is your usual point of contact on projects? (architect, contractor, client....etc)**

BI06-A: It's normally the architects who want us involved at an early stage. I think you go back 10 years and architects understood the building regs inside out and were able to apply it, but now there's so much  
85 legislation that they have to apply and consider like the various sustainability codes, the BREEAM ratings, the EcoHomes and the challenges of planning, which seem to be getting ever more stringent, the risk of it being called in for review and obviously the ever increasing complexity of the building regulations and secure by design, so much to consider. And I think today the architects want us to be involved because quite often architects, they're not fully up to speed on the building regulations and they're using us more as consultants to  
90 come in and help them on how to achieve compliance.

**IN: Do you view this to be the ideal person to interface with?**

BI06-B: I think we'd prefer to deal with the architects because they have the lead role in the design of the project. Sometimes we deal with project managers and some of the more enlightened project managers will push for our appointment at an early stage because they've seen the value of getting the design frozen earlier.

95 BI06-A: I think the clients are now starting to get us involved at an early stage, I think they're starting to see. I think it's taking a little longer, but I think clients-now in the current climate, there aren't so many- want to have far greater improved portfolios and they are looking to sell. So, certainly the hotel sector, the retail sector- we work with a number of the leading supermarket chains, one of the top four- they're very switched on to sustainable issues and the application of Part L. And I think also the office developers, I think they're more  
100 switched on because they know once they've built a building they want to advertise it as BREEAM excellent and we're now looking at things which they want to achieve, you know BREEAM outstanding, the new level.

So you've found that as time has gone on, people are more keen to get approved inspectors involved?

BI06-A: Absolutely.

105 BI06-B: Yes. They see it as if they get a good energy efficient building, they see it as a big marketing tool because anybody taking on that building will know that they're energy costs we be reduced as much as possible and that is a big selling point and will become a bit selling point. And the clients which are switched on are aware of this and are pushing for it.

**IN: Are they the person responsible for the Part L2A compliance simulation/calculation work?**

BI06-A: No. Quite often it's the M&E consultant.

- 110 BI06-B: Quite often they sub-contract it to specialist energy consultants on that basis.  
**IN: Which calculation tools/ methods are most frequently used to carry out this work?**  
 BI06-B: SBEM, BREEAM  
 BI06-A: Tas.  
 BI06-B: Those are the two which kind of jump to mind. There's one as well, there's a Glasgow based firm  
 115 doing it-IES.  
**IN: With regard to Part L2A compliance, what kind of information do you require to be submitted? (e.g. modelling assumptions, HVAC systems..etc.)**  
 BI06-B: We would need the BRUKL document on that just showing the notional and proposed, heat loss and thermal efficiencies for the building, so that information.  
 120 **IN: Do you require that they submit any information about modelling assumptions?**  
 BI06-B: Yes we would, on the bigger buildings we would have a modelling calculation, just to confirm that their input and design assumptions are what they say they are. And we would also look at if it's a non-standard thermal calculation and all that to confirm that the thermal value they're specifying can be achieved with the product they're specifying.  
 125 **IN: Do you require that they submitting the Part L2A work be certified under either of the accreditation schemes? How do you gauge their competency?**  
 BI06-B: That would be a preferred option. If the calculations show compliance, then that's all we can ask them from the building regulations. So it would make life easier if they were accredited because we would then just do a cursory check of their submissions, but if they're not accredited, we would then carry out a more detailed  
 130 check to confirm what they're saying applies.  
**IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route? (e.g. for overheating)**  
 BI06-B: Yes, obviously the NCM is only one way of demonstrating compliance with the building regulations and there are other options available. So we wouldn't limit the submission of information just to the NCM  
 135 package. So as long as the information provided complies with the functional requirements of the building regulations, then we would look at it and assess it on that basis and comment on that basis.  
**IN: What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?**  
 BI06-B: It would be normal checks against what the CIBSE guides ... etc recommend and just checking against  
 140 the publications that are out there to make sure it complies.  
**IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**  
 BI06-B: Obviously, our primary concern is health and safety of occupiers and people around the building, and I think no matter how you emphasise the requirements of Part L, the health and safety will always take  
 145 precedence over it. And again Part M and the DDA, because that affects people on a daily basis, whereas energy efficiency is something in the background and you can't necessarily (or members of the public can't necessarily) quantify it. Where if you try to get into a building and there are there steps or something, that's immediately visible and you think 'hang on, that's not ramped'.  
 BI06-A: And fire safety, I think there's three parts; Part M-access in and around the building for the disabled,  
 150 Part L-on the thermal and Part B-fire safety, those are the three documents that (we associate legislation with), so using the HDM codes and various codes for hospitals or the building bulletins for schools, those are the ones that we're using heavily for when we are involved at concept stages, Stage C. And I think probably, the biggest impact, the biggest part of the question to note from input from building control is on fire safety on Part B.  
 155 **IN: Do you think that the importance of Part L and energy efficiency has increased in the past few years?**  
 BI06-A: I think it's moved up the agenda, because I think it's become more of a headache for the design teams, to be perfectly honest.  
 BI06-B: I would agree with that. Before the 2006 regulations, it was fairly straightforward to achieve compliance with Part L. Now that the changes have come in, it's a lot more work for the design team to show  
 160 compliance for the buildings. And again, it will also go up the agenda because of the climate change issues as well, people are becoming more and more aware that we need to do something with the property stock within the country to make sure that we cut down on our CO<sub>2</sub> emissions.  
**IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?**

165 BI06-B: We've got a checklist and a tracking schedule which we issue to the design team from the beginning. And we will then detail what information we require to demonstrate compliance with all regulations, and Part L is on there. And that is a live document which runs through the duration of the project, from Stage C or when we are appointed through to completion and that is constantly updated, it gets bounced back and forth between us and the design team. We fill it in and ask for information, they send it back with details of what  
170 they've provided, then we send it back and say 'we need this, this and this' and that's the way we track the changes for Part L.

**IN: That's something you have here at your company?**

BI06-A: Yes, so there would be- I'm looking at one now- the tracking schedule split down to the various parts of the building regs. Under Part L there's 8 points that we would be asking for. So this would be provided to  
175 the design team. Point 1 would be-provide details of U-Values used for the envelope and manufacturers calculations, 2- provide Part L report, 3-provide metering strategy, 4-provide air test result and company used for testing, 5- provide light efficiency table, 6-provide log book TM-31, 7-provide EPC at completion stage and 8-provide solar overheating calculation. So we would be asking for those things over the period of the design period. And each document has the same.

180 BI06-B: Those would be expanded as necessary to go into further detail, depending on what information we get back from the design team.

BI06-A: That's fairly generic for all projects, but then obviously depending on the projects they would change and adapt.

**IN: What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance and what are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision? (i.e.-structural changes to the system, changes to the roles and responsibilities of key players...etc) and how would you recommend that these be dealt with?**

BI06-B: The main issues the design stage is the knowledge and the understanding of the design team of what's required to demonstrate compliance. They sometimes aren't aware of the detailed information that's required  
190 now to show compliance. They think 'we'll just do U-Value calculations and just state to comply with Part L', which obviously isn't sufficient. So I think there needs to be more education within the industry as to how to comply with Part L and that will only come through time.

BI06-A: I think it's also the difference that the use of the robust details and air testing. And I think with the air testing as a problem I think that then comes down to workmanship on site and that's an issue. And the  
195 application of the consequential improvements that we were talking about earlier on the existing stock and conflicts of Grade-2 listed buildings and planning requirements, and the conflict between planning and building control in the application of Part L on consequential improvements.

BI06-B: Yes, we certainly have come across submissions with air testing where for thermal continuity on site. Even though the architect will have done a nice detail showing the thermal continuity between the junction of  
200 the roof and walls, for example, the guys on site installing it will never have viewed that, so they will just leave it out because they will say 'no it's not necessary, it's just a small bit' and that obviously has a knock-on effect on the thermal performance of the building. And again with air testing you find that you either don't have it properly sealed to begin with or it's sealed then somebody comes along and knocks a load of holes in the fabric, which then when it comes to air testing which leads to a failure. And those two are the main issues.

205 **IN: How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period)**

BI06-A: I think the 4 year period, I think anything less than that would cause even more of a headache for not necessarily the building control industry, but I think more for the architects. And the development of the software as well, that's always been an issue, waiting for software to be produced. And that needs to be  
210 brought in much quicker. And I think the legislation is released, we're having to apply it, architects and M&E are having to work to it, the contractors are having to build to it, but the software isn't out there to use.

BI06-B: I think that the 4 year period is ok, it shouldn't be any less than that between reviews. But we need a longer lead-in period.

**IN: So the current 6 month stand-still period is not enough?**

215 BI06-B: I don't think so because you get some projects which have been in the planning stage 2 or 3 or 4 years and just as about they're going to go out to tender, they get hit by the changes to the building regulations- not necessarily Part L, but any changes-and then they've got to go back and review their design to make sure that it complies with the regulations. That I think is a big issue for the industry.

**IN: So a longer standstill period would be preferred?**

220 BI06-B: Yes.

BI06-A: I think also sticking to a program. We've been waiting for the new consultation document to be released. We were originally told February, then we were told March, we're now into May.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

225 BI06-B: The overall procedure is quite complicated and it's a headache for the designers and the contractors out there. But I think it's something which I think the industry, if they haven't realised now that they will soon realise, is something that has to be done and there's no way that we can skirt around the issue. How it can be improved is how I mentioned earlier is a longer lead-in time and, as (my colleague) was saying, set dates for issuing the changes to the regulations so the industry can plan ahead. So at the moment, the new Part L consultation is due out soon and implementing in 2011, but do we know when the next set of changes are coming out? You need to be able to look forward and see where the industry is going and what regulations are changing and if the government fix the dates for each review for each different part of the regulations, I think that would be a big improvement from the system that we've got now, because the industry doesn't necessarily know what regulations are going to change when.

230

## B Interview 07 Transcript

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI07: Our projects are mostly commercial and range from anything really from about \$100,000 worth up to I guess, the biggest project on our books at the moment is about \$80 million, I would have thought something like that. So, fairly large projects. As I said, they're mostly commercial. We do do some domestic, but not really as much. So we're mostly in the commercial field.

**IN: So usually office buildings?**

BI07: It varies. Some office buildings, we've got a lot of university buildings, hospital buildings. We do office buildings, but they've kind of died off in the last year or so because of the problems with financing them, I think. And a lot of specialist buildings as well, we do a lot of work with (a car company), so a few specialist buildings for them.

**IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

BI07: We're approved inspectors, so basically our role is appointed to the design team or directly to the client to assess compliance under the building regulations for projects across the whole range of the building regulations, not only Part L.

**IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006? (increase in workload, costs...etc)**

BI07: No changes as such, other than the fact that everybody attended seminars and training and what have you to see what the new Part L was all about. And at that time it became quite apparent that everyone was a bit ahead of themselves and that it wasn't going to work very well, as it proved it didn't to start with. And nobody really understood how the methodology worked and the methodology itself didn't really work that well at all to start with. So in terms of how it affected us directly; some body in here was appointed as the 'expert' to kind of see everybody else's input into that, and that person would be me.

**IN: So was there an increase in workload...etc.**

BI07: I mean, yes. Although the government's assessment was that it wasn't going to provide any more work to local authorities, I think it did. Simply because nobody knew how the whole new system would work and therefore there was a lot more work involved in trying to work out what it all meant to everybody because it was a complete change from the previous system that we had been used to. So the new way of looking at it basically, it seems to the outside it basically seems to be just a case of providing us with a calculation, job done as far as they were concerned they complied to Part L, that's all they need to do. We saw it differently, we say that the calculation was just part of it. There was the design stage calculation, then you went on to, you obviously needed an as-built calculation. And then there was also, there was the ongoing documentation you needed to show that the services equipment actually going into the building met the supporting documentation not just what it said in the calculation. So we had to do a lot of work with our consultants. We worked with them all the time to show that we didn't just need the calculation, we wanted the supporting documents as well.

**IN: Did you receive any training with regard to the new technical requirements of the Part L2A amendments? You mentioned that you attended seminars?**

BI07: I think they were organised by the CLG or whatever they were called at the time, to bring it online.

**IN: So they were just day seminars?**

BI07: Yes, nothing more than that.

**IN: What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?**

BI07: It's grown, certainly, since 2006 and we were aware of SBEM and that was all to start with and then gradually became aware of the other, more detailed analysis software packages that became available like Tas and the other ones, IES yes. And just recently, I've become more involved in it because I've just become accredited as a non-domestic energy assessor as well. So I've done the SBEM course and have become accredited separately for that.

**IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance?**

BI07: It's clumsy. It's becoming more and more effective in terms of the fact that you can model things in a detailed way in it. But certainly to start with, it was extremely clumsy and you couldn't get anything to pass unless it has some form of heat pump or something out of the ordinary in the building. You couldn't get a traditional building to work at all easily in it. So I think whereas it seemed that using IES or Tas they seemed to get the building to work more effectively than using those design tools. So the SBEM is getting better, but is still quite complicated in certainly inputting now we know what is involved in inputting the data into it. It is a



55 complex and not at all user-friendly tool to use. And it's no very intuitive either, it doesn't follow any- I mean if you're used to using windows or computers generally, it doesn't follow any logical pattern it seems. And there's quite a lot of the measurements that you need to take and how you need to describe certain elements that don't follow traditional building patterns either. I find it clumsy tool.

60 **IN: At which stage of the design process does your involvement usually begin? Do you think involvement at this stage is effective in ensuring Part L2A compliance?**

65 BI07: It can vary really. Sometimes it depends on who we're appointed by. If we're appointed by a design/build contractor they we might not be appointed till quite late on. Just before they begin on site, perhaps. So it's quite late on and all the design has been in place architecturally, for structure and for Part L, so we might not have any early input at all. If we're appointed by a design team or an architect direct or brought on board on a project early on, then quite often we'll be brought on board pre-planning stage, so you might have more of an input in terms of guidance. Early on in the new Part L, we were trying to encourage people to get us on board earlier, simply so we could help them through any of the complex processes. More and more, obviously, as the consulting engineers and mechanical engineers have got more and more used to the system and how the models work, it's been less of a task for us actually. Certainly the larger M&E engineers are using the more flexible modelling systems anyway, so they're not coming across too much of the problems of using SBEM on its own. So we try to get in as early as possible, but we're limited by when we're appointed to a project.

70 **IN: At which stage would you prefer this to occur?**

BI07: I think pre-planning stage, that would our ideal time, before planning permission has been applied for.

75 **IN: Please describe the impact of your involvement on the development of projects.**

BI07: I mean once we're appointed, we will ask to look at the design model for Part L compliance as early as they can make it available. If requested, we will meet the design team to go through any particular issues they've got and try to iron out any implications they see coming out of Part L. I've had a large project recently, I guess it was 2007 when it was implemented but it is still on site at the moment, and that involved a lot of processes that the M&E engineer wasn't sure to include within the parameters of the L2 compliance or not. So we sort of met with him and went through which processes we thought they could take out of the model because they were processes that weren't directly linked to the building and those processes were. And there was a lot of tie over between the two, because there were air-handling units that gave not only air to the building for people to occupy the building, but also there were bits of plant that also provided air-supply to machines and things, which weren't part of Part L, so it was how to try to identify pulling out bits and bobs of the machinery out of the Part L compliance. That's not on every single building, because on most buildings it's fairly straight forward, you know, it's just the direct building services.

85 **IN: Who is your usual point of contact on projects? (architect, contractor, client....etc)**

BI07: It could anybody, really. From the project manager, through the architect, through the mechanical and electrical engineers. So it varies from project to project, to be honest.

90 **IN: Do you view this to be the ideal person to interface with? who would you prefer, and why?**

BI07: I think direct with the architect from the building point of view and the detailing of the construction through to the M&E engineer for the services, rather than a project manager or – those are the two key people who technically will have the technical knowledge to answer any queries.

95 **IN: Are they the person responsible for the Part L2A compliance simulation/calculation work?**

BI07: Yes, I would have thought that they both would be equally. You the way that most of the projects we seem to work on, is that the actual calculation is produced by the M&E engineer, but all the architectural U-Values and what have you are given by the architect to the M&E engineer in the first place. So quite often it's a case that the architect might ask us a question about whether he thinks that a certain construction is suitable for use. And quite often my answer has to be 'well until we can model it, it will be difficult to say whether or not it will have a big effect on it'. I can go through the bottom out U-Values that Part L gives you, but as I say to them, you can't use lots of low U-Values and expect it to pass. You might get away with several low U-Values, but unless you've got a very, very high-efficient plant you're going to have a big effect on the actual overall outcome.

105 **IN: Which calculation tools/ methods are most frequently used to carry out this work?**

BI07: Well, As I mentioned earlier, Tas and IES are the two that we see from the larger M&E engineers, SBEM from the smaller ones and Hevacomp is another one we see some from, that tends to be from the middle range M&E engineers, so I guess it's because it's a cheaper program to use.

**IN: They would also use it for other purposes.**

- 110 BI07: I think we've certainly heard it from M&E engineers say that it's more clumsy to use.  
**IN: With regard to Part L2A compliance, what kind of information do you require to be submitted? (e.g. modelling assumptions, HVAC systems..etc.)**  
 BI07: It seems that both Tas and IES now have come up with a-they provide quite a detailed breakdown of compliance. They provide a Part L2 compliance document, basically, which just about gives you all the  
 115 information that you need. If you get someone that gives you just SBEM, then that doesn't really provide you with the background information to show that the equipment meets the non-domestic heating and compliance guide. So we quite often ask for-if we just get an SBEM calculation- then we'll ask for additional information on top of (that).  
**IN: So you'll ask for modelling assumptions?**  
 120 BI07: U-Values and efficiencies of plant and lighting efficacies and that sort of thing that aren't included, whereas I say that the most recent one I have, which I think was Tas had a full break down, had a load and efficacy calculation and all the efficiencies of the plant. So it was all in there, so you didn't need to ask for any more information, because it was all included.  
**IN: Do you require that they submitting the Part L2A work be certified under either of the accreditation schemes? How do you gauge their competency?**  
 125 BI07: I don't think you can actually require them to be. So we would look to see if they knew what they were doing. If you've got an SBEM calculation from someone who had just downloaded the program for free as you're told to do so and 'give it a go', then I would think I would probably be able to tell that they weren't kind of on the ball with it. But I would think that if someone's, if an organisation has already got Tas or IES or  
 130 something like that, they need to be accredited by the IES or the Tas company to actually use that software. So perhaps you would think that they knew what they were talking about and you would perhaps give them a less detailed look, but you would certainly recognise that the knowledge would be more in-depth than probably your or probably my knowledge. Whereas an SBEM collation coming from a smaller company you would perhaps give it a bit more finer detailed look at because it's got more potential for having problems with efficiencies and U-Values.  
 135 **IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route? (e.g. for overheating)**  
 BI07: I don't think I've seen anything other than the three I've mentioned. There are other tools that have been accredited, but I don't think I've seen any other ones then. But yes, if we had a Part L2 compliance document  
 140 in from another system I didn't recognise, then I would certainly look into the accreditation of it. But we quite often, if we get an SBEM calculation, of course it doesn't cover the solar overheating calculation on its own, so we would ordinarily ask for separate solar overheating calculations. But that wouldn't necessarily be a model, that might be by hand. If someone can actually do the calculation and show that they meet the CIBSE guide for solar overheating, then fine. If they choose to do it longhand, then so be it.  
 145 **IN: What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?**  
 BI07: As I say, we go through them with a fine tooth comb to certainly check the U-Values and we would for instance check the U-Values against the architects details to ensure that they do match up. Because quite often  
 150 M&E engineers will use their own U-Values and they don't match that to the architects details at all. So if we get just a set of SBEM calcs or whoever's calculations they are, and it quotes the U-Values and we don't have those from the architect, then we'll ask for a breakdown of U-Values to show that they've met them. We go into the details of asking for efficiencies of the plant to ensure that whatever they're quoting in the documentation is also what they're actually using for the plant in the design stage and certainly for the as-built stage. Unless it's already in the document and they're showing the plant information, then we'll go through it  
 155 in detail.  
**IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**  
 BI07: I suppose fairly high, I think when we're brought on board to any size project, probably the first and most important thing we look at is Part B (fire safety, means of escape and that sort of thing), that's probably  
 160 our main thing. And then I would think, closely followed by either Part L or Part M (for disabled) would probably come in second, a close second and look at all that sort of information really. So, fairly high but not quite at the top.  
**IN: Has its priority changed in the past few years?**  
 BI07: Yes definitely, because before it was quite low down and people would just ask for U-Values at some

165 point and make sure they comply. But these days because it's such an important part to make sure a project comes up to scratch at the end of it.

**IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?**

170 BI07: I mean it's difficult because all the procedures from different AIs and authorities are going to be different. Here we'll ask for an SBEM at design stage or whatever tool they're using to show compliance at design stage and then again we'll ask for it again at completion and a rolling program of queries could be brought up and answered during the tie between the two. And depending on the complexity of the project, I think they are provided that they are kept- we certainly see different variances in site control, management and understanding in terms of how important the Part L compliance is. There are sites that recognise the importance of air-tightness for instance and go to great detail to ensure that the construction details on site will meet the standard when it comes to air pressure testing, there are other sites that just wing it and hope that it's going to pass. We certainly see that and we still get jobs now that fail their air tightness test. Within their calculation at design stage it might be an air-pressure test of 6 or 7 or something like that. And I still get ones now, I had one the other day that only achieved 12 or 13 on its first attempt on air-tightness, which is quite bad really considering the design was 6 and it took them 3 goes I think to get that down to 6. So there's quite a variance, but we re-iterate it at the pertinent stage on site to ensure that they will meet the standards.

**IN: What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance?**

185 BI07: I think it's the understanding of the whole thing really and the change of the culture from the previous Part L to the new Part L was fundamental in creating a lot of issues with architects and M&E engineers. It's got less and less, as I said earlier, certainly in the last 18 months or so I think, because of more and more understanding of the compliance routes and certainly from the architect's point of view in terms of the air-tightness and the thermal bridging aspects, they've become more and more aware of how to overcome issues.

**IN: Is industry becoming more comfortable?**

190 BI07: They are becoming more resigned to it, perhaps. They are starting to understand it more. But I think the methodology has become easier to understand and certainly the SBEM reports themselves- when the EPCs came online- they eventually upgraded the output document, because the original SBEM output document was a terrible thing to read and understand, it didn't tell you anything. At least now it's clearer. It still tells you the same sort of information, but it's clearer to understand and I think that helps a lot. But I still think there's a big issue out there certainly with smaller and medium sized architects and developers that they produce that document and that's it, that's what they have to do and we get feedback that that is accepted by certain local authorities as being compliant. But we don't see it that way, we say well, that's one part of it but you also need to show that your plant meets the non-domestic heating and cooling compliance guide. You still need to provide information to show you meet the solar overheating requirement and so on. So there's lots of things that aren't covered by that and there's still people out there who think that's what they're supposed to do. So we still think there's not enough guidance given on that so we will always make that clear when we're appointed that it's not just-if you're going to use SBEM-then you must be aware that there's lots of other information that you must provide as well.

205 **IN: What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision? (i.e.- structural changes to the system, changes to the roles and responsibilities of key players...etc) and how would you recommend that these be dealt with?**

210 BI07: If they are going to continue using SBEM, which I guess they are, because they've invested a lot of time and effort into it, then it's a clumsy tool anyway because of its Windows Access based basis, so it's never going to be as user friendly as some of the other tools. Not that I've used the other tools, but from people I know working in other organisations that have used the other tools, they are much easier to use. They might be more detailed, but they're much more user friendly.

215 So I don't know how much development they can put into SBEM to make it more user friendly. It would be great if they could come up with a user interface to the front-end that makes it easier to use and some of the actual methods of putting in some of the actual dimensions and things like that would make it easier to understand. But apart from that I don't know what else they could really do. It would be really good to have more impetus put to make sure that everyone was asking for the same information, efficiencies of plant and solar overheating which does get overlooked.

**IN: So make input requirements uniform?**

BI07: Yes, that would be good, make them more obvious and make them easier to understand would be a key

220 thing I think.

**IN: Is there anything with regard to the actual regulations or methodology?**

225 BI07: I think it needs to be made easier to understand and perhaps that will be a way to – because most architects and developers will probably not attempt to look at Part L and attempt to understand it, they will give it to a consultant to sort out. It's become easier to understand because of using it over the time period of the last couple of years, I would hate to think that they would now change it completely, because you get used to one set and what's the point of changing it again no we've gotten used to it. It would be more useful to refine what they've got rather than change it completely.

**IN: How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period) Do you think the current 4 year cyclic review period is sufficient?**

230 BI07: I think it is as long as there is no major change like there is from 2002 to 2006, because that was too much of a major change to come in within that timeframe. They should have given that a longer lead-in period for sure. I think that's widely known, everyone says that. So I think if they are going to be reviewed next year and if they are just going to tighten up things like say bring the air-tightness figure down a bit and tightens up a few other little bit, then that's fine, if it's just a refinement of what's there to bring the whole CO<sub>2</sub> outputs  
235 down. But if there's any major changes, then there needs to be a longer lead-in period. I don't think 6 months is a long enough lead-in period, I think you need a year once you've got a new document in place just to give people an opportunity to understand it. And they certainly have the change-over lead-in requirement like they did for the last Part L, but that needs to be a longer period to give people more of a chance to catch up.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

240 BI07: It was certainly very bad to start with, it's gotten better and as ones understanding gets better with it, you can get to grips with it better. And certainly having done the EPC course, I can understand how it all works, but it's still a very clumsy tool using SBEM and I guess with unlimited resources, you would design a simpler tool. So the simplified building energy model would be a simplified building energy model and wouldn't be as complex as it is to use. That would be, I think, the ideal thing, but unfortunately it's never  
245 going to be as simple as something like SAP, because most of the buildings are far more complicated. I think it's important that the developers and the building control bodies need to be aware that there's other things than the SBEM to comply with Part L. So whether SBEM, or whatever tool is used, could be increased in scope to cover those other areas would perhaps be useful that when you do get a calculation that it does cover everything in Part L, like it does in Tas and IES it covers everything in Part L and gives you all the calculations  
250 for solar overheating and efficacies all covered by their documents. But it's not with SBEM, so maybe they could look at that as an improvement would be useful.

## **B Interview 08 Transcript**

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI08-A: Anything at all that comes up within the borough. So we have the biggest at the moment is 300 million, smallest below a thousand.

**IN: Are they commercial or domestic projects?**

5 BI08-A: Everything

**IN: So office buildings, things of that nature?**

BI08-A: Yes

**IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

10 BI08-A: To ensure that the building regulations are adhered to and complied with. And in certain instances, because our very, very large job that we have-the 300 million pound job-is not just based on the building regulations, it's also based on certain European legislation and United States of America legislation as well, because of the insurance company. So yes, it's a big learning curve, but basically we're here to make sure that the building act and the building regulations are fully adhered to.

**IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006?**

15 BI08-A: In 2006, nothing. Because our previous senior building control manager basically didn't do anything. We started last year, that's when everybody started really, it was early 2008. We had nobody qualified at the time. I actually was appointed in October 2007, that would've been. Obviously it took time to get everything as to where we were going, what we were doing and the position we were in. And then we had staff do both  
20 SAPs and EPCs for domestic and Kerrie to undertake the non-domestic, which she is at now Level 3 and she will carry on and do Level 4 next year.

**IN: So was there an increase in workload?**

BI08-A: Yes, but that was purely and simply because that's the reason we did it. Because we wanted the additional workload. So we actually now do Energy Performance Certificates for housing associations to get in  
25 more fees, we do SAP calculations for anywhere in the country and we do them on our own applications as well. So the idea is to get more fees from it.

**IN: Did you receive any training with regard to the new technical requirements of the Part L2A amendments? Please describe (method, duration, effectiveness...etc)**

BI08-B: Yes, I think I went on some Part L training, didn't I?

30 BI08-A: Yes, probably I mean when it came to Part L itself when it came in, I did the PowerPoint presentation to all the staff. And basically when it came in, the government made a complete and utter hash of the whole thing. I wrote a PowerPoint presentation which we'd already given to the agents who submit applications in Bexley, only to then find that a month before the regulations came in they changed them all. And therefore it was a complete and utter lash up, there's no other word for it. We then obviously had to retrain staff,  
35 predominantly to start off in that month. And up to a point, I would have said that staff in the office, Kerrie being the later one because she wasn't here at the time when obviously that came in, probably picked up Part L as we've gone along. Kerrie's perspective probably, has in the main because where we want her experience to lie, has been with regard to L2, whereas (our colleagues) we obviously want the in the main to be L1, because obviously they're doing the domestic. But the overall umbrella checking for L2 would come under me.

40 **IN: So there were seminars given here in addition to some people going out for external training?**

BI08-A: Yes, you went to one in Tower Hamlets, didn't you?

BI08-B: Yes.

BI08-A: I'm just trying to think, (our colleague) went on another one for Part L and then we obviously gave our own seminars in here as well.

45 **IN: What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?**

BI08-A: I suppose, one I'd like to think that, I hope my knowledge is satisfactory and sufficiently in depth to obviously be able to write anything we need to applicants, if anything is wrong in order to get compliance. Obviously, if it then needs the specific involvement of either non-domestic or domestic for SAPs or EPCs, then  
50 that will be dealt with by the relevant people with the qualifications for that.

**IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance?**

BI08-A: You better answer that.

BI08-B: When you say that, I've not really been involved with Part L on the commercial, it's the Energy Performance Certificates. So you can use SBEM for those 2 purposes, but they are different. So I use SBEM or

55 EPCs, I'm not trained for Part L.

BI08-A: No not at the moment, that's in the future. With regard to the rest of it, probably I would say that as with everything else in the regulations, when they first started back in 1966 everything was very simple. Unfortunately the regulations have now become so complex, that you really need experts within your building control team for every single section and consequently I would say that although I would hope that we are  
60 complying fully, obviously at the end of the day anything can be made simpler in order to make it a lot easier and quicker to use. But it's, yes it's relatively understandable.

**IN: At which stage of the design process does your involvement usually begin?**

BI08-A: We operate systems that are, where applications come across the county in the first instance and at that stage I would say probably less than 5% of these we've seen before they're deposited, on any type of  
65 scheme. Any local authority though does get involved in what is called 'partnering of applications'. So a partner application is where all local authorities who have signed up across England and Wales will accept that we can have applications submitted as we have at the moment for (a supermarket chain) and that is being checked by (an England) City Council for the building regulations, but we're doing the site inspection work because it's in Bexley. (A department store) was another one where Birmingham City Council checked the  
70 drawings because they come from that area and they have an agreement with Birmingham and then when it was dealt with in Bexley Heath, we then dealt with the work on site. We also have at the present moment in time, it basically deals with the whole of the southern counties of England and one other group, where we check for all their county council work in that way. And in the present moment in time, we're being asked to be involved in an outsourcing of work from a specific number of councils elsewhere in the country, where  
75 obviously we're being asked again for our support for building control and therefore we may well check applications in the future for something that is 150 miles away. So in those cases, when you have partnering, you have far more involvement with the people early on in the scheme. So they won't have designed a scheme fully and therefore the hope of that is, from our perspective as well as theirs, that they can design problems out, rather than obviously submitting it as a completed scheme and then all of a sudden there's something  
80 wrong with it. I'd say a maximum of our application I'd say about 10% is non-domestic, that's probably the easiest way and probably 1% or 2% on domestic applications.

**IN: So do you prefer to be involved at an earlier stage?**

BI08-A: Absolutely. I mean you've only got to do the work once, anyway, and it's far easier to do it at an early stage because you can suggest something that is far cheaper, but still complies. Basically, once you've got , let's  
85 assume you've got a building where you've got floor plans, obviously for us to be able to check it we've got to have sufficient 'meat' that is then put on to the drawings to be able to enable us to establish what it is that we're meant to be advising people on.

**IN: Please describe the impact of your involvement on the development of projects.**

BI08-A: All that happens is that either the consultants will come in to see use or we'll go their offices and we'll  
90 be aware before we go, or we'll have a meeting here of what it is that needs to be discussed in order obviously to make the meeting far more accessible to everybody that's attending and keep it as short as possible. And what obviously needs to be discussed, is what we'll deal with. You can't define anything specifically, because you don't know before each job comes in what it is you're being asked to do.

**IN: Who is your usual point of contact on projects? (architect, contractor, client....etc)**

BI08-A: Initially what happens is that I check all the build regulations applications for the borough and therefore for the checking purposes, it will be me that people come in and discuss it with. I will interface either  
95 with the client or the architect, the mechanical or the electrical engineer or a surveyor. If it's just with regard to Part L, it would normally be just a mechanical or electrical engineer or a combined person. But obviously, it's important that the client is aware and is involved, if they wish to be as to how their money is being spent and how it is being spent.  
100

**IN: With regard to Part L2A, who do you prefer to interface with, the mechanical engineer?**

BI08-A: It doesn't make any difference to us.

**IN: Are the mechanical engineers the people responsible for the Part L2A compliance work.**

BI08-A: Well it would normally be somebody who is, I would say, mechanical or electrical would deal with it.  
105 Obviously, both people would need to be involved. Or very unusually, you get a conjoined person who is both mechanical and electrical. But both parties have got to be involved in order to have the information provided.

**IN: Are they the people who also do the simulation/calculation work?**

BI08-A: They may be. Just depend if they are sufficiently qualified in that respect. I mean, yes, I look at the regulations for the building regulations, but I'm not the person who does the EPCs or the SAPs. That's a

- specialist within the group who deals with that.
- IN: Which calculation tools/ methods are most frequently used to carry out this work?**
- BI08-B: I suppose SBEM is the favourite.
- BI08-A: In fact, I'm not aware that we've had anything other than SBEM.
- IN: Even for bigger projects?**
- BI08-A: Yes.
- IN: With regard to Part L2A compliance, what kind of information do you require to be submitted?**
- BI08-A: I'm afraid this is going to be a very, very silly answer; whatever is needed depending on what is included in the application. Because until you know what the application consists of, you can't really say what it is that you want.
- IN: So it might be something as detailed as looking at modelling assumptions?**
- BI08-A: It could be, depending on the size and type of the scheme.
- IN: Do you require that they submitting the Part L2A work be certified under either of the accreditation schemes?**
- BI08-A: Yes.
- IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route? (e.g. for overheating)**
- BI08-A: Well even if you do deal with solar issues, that should still be included within the SBEM.
- IN: But SBEM doesn't do solar overheating.**
- BI08-A: Well we have it attached to it and there is a BRE document that actually does deal with it. So we would expect that to be attached to it.
- IN: What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?**
- BI08-A: I will have an initial look and then I will have a word with our estate services, who have a mechanical engineer. And when it comes to electrical, if here is anything we're not sure of, I'll get in touch with one of the electrical contractors who we deal with who have obviously people of a reasonable expertise in these things who we can the query. Because we don't have all of the necessary expertise within the building.
- IN: So you go to relevant experts?**
- BI08-A: Yes.
- IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**
- BI08-A: I think the easy way of answering that is the CLG feel that it is absolutely imperative that local authorities do comply. My opinion is that a vast number of authorities don't give it the necessary amount of weight that they should do. Suffice to say that I'm aware that there are quite a lot of London boroughs that don't have people who are qualified at any form with regard to Part L. We went to the LABC conference at the end of March when one of the deputy directors in the CLG stated that she thought that local authorities weren't giving sufficient credence for Part L. And we then came back from that and albeit that it initially is, for all of Part not just L2, we now make sure that all of our schemes that we go on no matter how big or small, every single inspection has photographs taken of every single element that is undertaken on a scheme in order for us to say 'yes we have seen it and we can prove what was done'. And we now have a thermal imaging camera which we didn't have before. So again particularly with if we're uncertain if something doesn't comply, when we're then on site, we are able to prove that that is the case.
- IN: So how would it rank in terms of importance?**
- BI08-A: From my perspective, just the same as everything else. The parts of the regulation are there to follow and you follow them. And therefore as far as I'm concerned, you shouldn't give it any greater credence from one to another. So I would treat Part A or E or L the same.
- IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance? You mentioned site inspections?**
- BI08-A: I personally don't do them, but the staff ensure that when an application is approved we have the necessary details that show that compliance is followed fully. So consequently, we will check or I will check the application in the first instance, we'll make sure that that is in place and then the site staff have all of that paperwork that they then make sure that that is followed through at the end of the job.
- IN: How important do you think that these checks are in assuring compliance?**
- BI08-A: It's imperative, because it's no different to anything else with the building. You take Part B, if you're

165 not checking to make sure that obviously things are undertaken, then basically fire can get through anywhere. Obviously, we can have cold bridging in the building with Part L, we could have issues that are not actually in place and therefore it will ruin the whole of the context of what are meant to be getting. It is very, very important,

170 **IN: What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance?**

175 BI08-A: I mean I would that very few of our applications are L2, anyway. Very, very few. And even the job we have at the moment, which is 300 million, most of that hasn't got to comply with Part L anyway because it consists of a waste heat transfer plant. So that the heat inside the building is 50C to work in it. So consequently, there's no way, obviously you want to keep the heat in, there is no heating as such for the building because it's the furnaces and the boilers that throw out the heat and you wish to dissipate it. But we only have one very small area that is storeys in an otherwise single storey building. So it's very critical, in the sense, for that small area that we insulate properly because otherwise we've got all that heat coming back in that we have no control over and therefore we're wasting energy trying to get rid of it again. So although we haven't got the details yet, we will have obviously the heat from the manufacturing process will be channelled in art into our 5-storey area, so it's there and we're using it and we've got to make sure that the rest of the heat stays outside and doesn't interfere with the people working in the offices and the control centre for the building. But we haven't dealt with that yet, we haven't got to that stage.

180 With regard to other buildings, we just purely look at it under SBEM and whatever id shown to comply under the regulations and that's it. Probably in a year, if we have 4 or 5 maybe.

185 **IN: And there's been no problems with those?**

BI08-A: None at all. We've got schools, we've had new schools, large school extensions. We've had some offices. We haven't had any problems with any of ours.

**IN: But you mentioned earlier that there were some initial problems with people understanding what was going on.**

190 BI08-A: Well, that was purely with regard to L1 rather than L2, because they changed the law a month before they brought it in. Which they've said next time, they're not going to do.

**IN: What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision? (i.e.- structural changes to the system, changes to the roles and responsibilities of key players...etc) and how would you recommend that these be dealt with?**

195 BI08-A: I went to a CIBSE conference 3 weeks ago and heard the guy from the CLG turn around and say 'it is imminent that we are going to give this detailed report out of the 600 page consultation'. Imminent, when it applied to March, meant that we got Part G out 10 days ago at the beginning of June. So basically 'imminent' there was 10 weeks. They obviously said that they don't know, almost certain that they will not get April next year as they had anticipated, it will be October and as far as I'm concerning it's going to be dead certain that it's going to be next October, even that I think they'd be lucky to hit because of the speed that they work at. But at the end of the day, for me it just reinforces the position that everything now is becoming so complicated and detailed. What on earth do we need a 600 page consultation document for? And at the present moment in time, I've also got to between now and the 26<sup>th</sup> turn around and put in with my immediate boss comments for the CLG on new fees for building regulations. And then we've also got at the same time risk-management, because we're now not having compulsory inspections any longer and we're now doing it by risk-management and consequently it happens that we're one of the trial authorities. So all of these things are going on at the same time and it's very easy when you're sitting in a department in Whitehall and someone says 'I'm producing a 600 page document'- because that's all you're doing, nothing else. Somebody then s doing the piece on fees, somebody then s doing the piece on risk-management ...etc. whereas the poor person on the blunt end, us, has got to deal with all those things together, including the job that we're meant to be doing. As well as trying to keep abreast of any new legislation.

210 **IN: So you think they should 'un-complicate' things?**

215 BI08-A: They go into things, I think, now are far more complicated and detailed than they need to and at the end of the day, the very last set (the future role of building control) – basically they produced a document that turned around that gave responses to the responses that they had received. If you actually read that properly you will see that every single thing in that document, is what they wanted. It's got nothing to do with the people that responded because they managed to turn everything on its head, when you read that.

And it's a very clever way of writing, because everybody could have written in and said, we didn't want A, we wanted B, but you can guarantee that A will be the thing that comes out in the report, because that s what



220 they want. And again, I'd much prefer there was honesty. If that's what they want, that's what they'll get. Don't waste peoples' time because so many people get involved in this, both in industry and local authority, who are fed up to the back teeth with the CLG and central government. So as far as I'm concerned, it's ridiculous.

I went up to the guy from CLG and Faber Maunsell and asked where the figure for the carbon came from for the country, who defines that that is the figure that's coming from housing? They didn't know. 'Well, somebody must have devised where it came from, so why don't you know?' 'Well because it really doesn't make any difference'. I said 'well it does if it is 100% wrong, I'm not suggesting it is, I just want to know where it's come from'. So we got to the point where I said 'you obviously turn around and say that the amount of carbon that is being emitted into the atmosphere from buildings, but you don't seem to take into account what the effect is with regard to buildings that are extended.' I must admit, I gave up at the end of the day.

230 Because of the area we're in and we may be a lot more inner London, they might not allow it in outer London so much, we have a lot of semi-detached houses that have a side space that has a 2-storey extension on it, it's a wrap-around 2-storey and where it's within 2 metres of the boundary again, the planners make them get down to a single storey. So there is at least 60% of the external envelope of the original building covered by new building. We have brand new double-glazed windows, a brand new condensing boiler because we need that anyway in conjunction with the extended building, we've got roofs that obviously have the full amount of thermal insulation for the whole building as well. And if you work out what you had as a DER and TER that was erected in the first place under a SAP calc and then worked out what you have as a DER and TER for an amended building, it's probably only 30% the amended building. It might be less than that. The amount of carbon therefore escaping from that building is so much more than it was when you started and you've made no allowance for that in the present regulations and it doesn't sound like you are going to in the revised ones either.

**IN: How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period)**

245 BI08-A: I think they've probably got it right now that they're going to do it every 5 years now isn't it? I think for me the only ridiculous situation is if we are that interested in energy saving measures, then what I cannot understand is why we have a sustainability code where we actually have a 25% betterment of the building regulations and the building regulations are meant to be the minimum standard. Why did we not bring that in when we brought the sustainability code in and do the whole thing in one go? We have so many steps in various areas where there is no consistency of approach and you're not going to turn around and get people to follow the sustainability code unless -like the housing co-operation- you enforce it. Builders aren't enforcing it, they're only going to what the regulations are.

**IN: But you think every four years is sufficient?**

255 BI08-A: I would say if there is anything that occurs technically that enables things to be increased or enhanced to a far better standard, then I think that could be brought in as and when they wanted. So if they wanted to change U-Values because all of a sudden, there was a marvellous way of producing windows of a far better U-Values, then that's fine. But I mean to actually, yes they shouldn't inker around the edges with calculations and things like that mostly.

**IN: And the lead-in period of 6 months, is that sufficient?**

260 BI08-A: Providing we had 6 months, that would be wonderful.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

265 BI08-A: I would have thought that initially, the government were at fault with changing Part L back in 2006 and didn't give enough people the time to bring it in properly. I am aware, for instance, that the whole county of Kent decided that they weren't going to bring it in and they wanted 6 months after it came into force for it to actually be dealt with. The CLG came down on them like a ton of bricks and attended all their meetings and said 'you will do'. Now it's all very well to say that but you've got to give people the time to get the expertise and then to put that into practice and so I think it probably took a very long time to get Part L accepted by everybody. I think because of the way it was brought in that there now is a lot of antagonism towards it by everybody, no matter now it's settled down, and I think we attempt now in every way to fully comply with Part L. I mean we don't allow anybody off with anything at all with Part L than we would with any part of the regulations.

## B Interview 09 Transcript

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI09: I'm currently working in the major projects team, so it's quite extensive, including (our area) developments so it's quite a range. And I've got a small patch which covers this locality so it ranges from normal residential to major projects. Fundamentally, its major projects over a billion and a half pounds.

5 **IN: So do you have offices...etc?**

BI09: Because it's (London area), you have offices buildings, the energy centre-which is just starting-to (a consultancy) designers and offices in (London area), all the way to just speculating-build offices. So it's quite a range of commercial buildings.

**IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

10 BI09: As a building control officer actually, I'm assigned to vet the applications from submission all the way through to completion of the project. So it ranges from actually vetting the applications, seeing the compliance in both approval stages up to actual approval then on site to actually see that the work is carried out in accordance with regulations.

15 **IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006? (increase in workload, costs...etc) and did you receive any training with regard to the new technical requirements of the Part L2A amendments? (If yes) please describe (method, duration, effectiveness...etc)**

BI09: Basically we had in-house training, where we organised external agents to actually come in and give us a talk on the actual thing. And then individual officers did their own- also at the same time- on the job type training. You know. As is goes 'thrown in the deep end and deal with it'- so it's quite extensive, but everyone's done it their different routes. But initially we had people coming in.

**IN: Did you notice that there was an increase in workload...etc?**

20 BI09: Yes, initially it was that people wanted to get out of doing what was required, but when they started dealing with it they didn't see that they were going to do that, but their client required it any way. So, it was an initial surge I think, there was an initial surge to try and avoid certain things, because of air-tightness tests or whatever- but initially it was that initial (surge) to try to get away with things.

**IN: What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?**

30 BI09: As I said, because of SBEM, which we required, fundamentally as it is a software application, from our point of view it's just input surrounding all the criteria are met and from the checklist it's all worked back. Different consultants are involved in the big projects, and they take it on board, so it's like handing it over to someone who's accredited to deal with it. We don't actually utilise software ourselves.

**IN: Are you familiar with the procedure?**

35 BI09: Yes, familiar with the procedures, but they got to do the procedure and have got to submit it to us. It's just one aspect of it.

**IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance? (expand to simulation tools)**

40 BI09: I think its complex, it's become extremely specialised. We are seen as a jack of all trades, but unless you do your further research and really look into the subject, there's so many different parts to it which have become very complex. And if it's not fully clued up, it came like any computer thing 'rubbish in-rubbish out' sort of basis.

**IN: So you think it's made things a bit more complex?**

BI09: It's made much things more complex.

**IN: At which stage of the design process does your involvement usually begin?**

45 BI09: We have it concurrent with planning because we have prelim sometimes years before the actual jobs is actually come in to get drawn up on basic principles.

**IN: So at design development?**

50 BI09: Yes, I mean we had it at the beginning of schemes and they can come in right at the start or we have clients who are partners and they come and they've got queries related to parts of the job. So to get principles tied up and then it could be a few years later, we have the actual application submission. So it's quite an extensive period which we can be involved in any project.

**IN: Do you think involvement early on is effective?**

BI09: Yes, I think because it's not coming as a shock to each side. You're prepared and you can possibly- coming back to the complexity- you can do your research and background on anything that's cropping up in

55 the prelim stage that you're not too sure about or require further guidance to the client, you can actually go  
and research that before and be more in depth when you've got an actual example to work with. Any subject,  
if you've got a particular angle that your focus is on specifically in a type of building; in a hotel you look at all  
that guidance related to hotels, so you would focus it on the actual examples which would make it easier, so it  
does help for all sides. So the earlier on the better, yes.

60 **IN: Please describe the impact of your involvement on the development of projects.**

BI09: Its fundamentally, the problem is that we're guidance, but we're also enforcing. So lots of times it's the  
fact that that we're trying to get the job running effectively and smoothly, but we're limited by what the  
legislation applies for that particular element of it which is related to energy. There's guidelines which have to  
be met, if it's strict or more onerous, that's as far, we can't really push it further than what the legislation  
allows us to.

65 **IN: So your role is mainly guidance?**

BI09: It's guidance yes, because you're forced to become-if they don't comply- then it's enforcement. So you're  
balancing between the two. It's getting that sort of thing where you're trying to encourage it with your added  
value of information, but it could be that the client might not want to hear that. So it's that balance of getting  
beyond (being) limited by your statutory requirements.

70 **IN: Who is your usual point of contact on projects? (architect, contractor, client....etc)**

BI09: Whoever provides the application. So the applicant would submit the application. So the architect is on  
the majority of jobs is the lead and they would have been on board. If it's specialists they would bring on the  
team in the prelim meetings, they might bring in the consultant aspect at that time to go through the  
principles. But they would generally be the point of contact.

75 **IN: Do you view this to be the ideal person to interface with?**

BI09: Yes, it's getting that co-ordination, because lots of the details are subject to what the architects envisage.  
So it's getting that whole team approach and that's what applies for all the other elements of the building regs.

**IN: So it's usually the team leader?**

80 BI09: Yes, the team leader.

**IN: Is the consultant the person responsible for the Part L2A compliance simulation/calculation work?**

BI09: Yes, I mean if they're the M&E side of the package of consultant relating to- or usually they're the same  
company doing the public health and also all the plants- so they've got to co-ordinate. But they might even  
have a specialist subgroup in that even more focused on just producing the SBEM calculations. But generally,  
on bigger projects it's the same team. The consultant would be utilised in that.

85 **IN: Which calculation tools/ methods are most frequently used to carry out this work? Is SBEM the most frequently used tool?**

BI09: They might have the modified SBEM-specialist things. Like (the consultancy) have come up with their  
own calculating (tool) because that might not be effective and SBEM is the only one which is accredited as far  
as we're concerned with actually having our own software to back it up. If they're going down that route it's  
like a rubber stamp, I mean it's giving us assurance. So I mean they're probably going to come up with other  
things to get around problems, but for us to say that's compliant, we haven't had anything else. So it's SBEM,  
because that's the only government accredited thing.

95 **IN: With regard to Part L2A compliance, what kind of information do you require to be submitted? (e.g. modelling assumptions, HVAC systems..etc.)**

BI09: As I said, all the package on the checklist - as far as getting all the actual, seeing what the actual scheme  
is and then we have our M&E colleagues who actually look at the aspect of the active sides or the systems and  
we look at the actual fabric envelope details. So it's getting all the- because now it's made up of so many little  
sub-packages. There's the global principles and then they get the subcontractors and consultants putting in all  
their little packages. It might just be one little element, but it's quite- that's why the architect co-ordinates that  
and we say input and then we get the actual prelim calcs and input from them.

100 **IN: So you'd ask for things like U-Values and fabric...etc.?**

BI09: Yes get the initial input, you know we can generally see what's going on. But the actual input of the data  
is totally subject at submission which will come on PDF or they'll send in nice glossy brochures showing  
compliance.

105 **IN: Do you require that the person submitting the Part L2A work be certified under either of the accreditation schemes?**

BI09: Basically on the projects we do on the level that's required generally de facto will fall into accredited  
things. We haven't had one man bands generally dealt with in the extent of the projects. So as far as we're

- concerned, they're accredited and as they're using accredited software, that's fine.
- IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route? (e.g. for overheating)**
- BI09: Anything if it's special. Generally, because we haven't had the actual training aspect, the confidence of that, as far as I'm aware it's not come to any alternative requirements or scenarios. Generally, it's been fairly standard. As I said, the industry out there have got set ways you know. But I haven't come across any.
- IN: What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?**
- BI09: Basically, it's the packages which you receive and the submission for the vetted application and then actually seeing on site. So basically you would have, because as I said you're doing your vetting, you've got your checklists and your tick boxes. Every officer would deal (with it) in a different way, but generally as I said it's working back from having a standard checklist from L2 in the back. Then we'll just follow through and then search on site that 'yes, they're using that. There's no change from the architects' details'. If there's changes, then we throw it back to the architect and say 'will it be amended in the design calculations and updated in the as-built?' So it's a balance, yes.
- IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**
- BI09: As I said, it's one additional aspect which is there.
- IN: Are they all equally important to you?**
- BI09: As building control, I can say health and safety is first. But it's still high (up), everything is really considered, but it's just the level. Health and safety is just the standard one, but it's still considered a main thing because we can't issue a completion certificate without that compliance.
- IN: Has it become more important in the past few years?**
- BI09: It's the trendy thing, but basically it's more things, it's done from one pamphlet, that's standard and then you get all sub-sections and things so it then becomes very onerous. But generally, because third parties are supplying us with information, generally they're specialists and they provide all the information we require.
- IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?**
- BI09: It's totally subject and dependant on the quality of the site supervision. Yet again, if there's a problem with the general build aspects of it, there's going to be problems with Part L because they're not going to have a sealed envelope if there's (problems) with details and air-tightness. So, at the end result we get the air-test, if that gets a good result then we're fairly confident that the building is sound. But it's just getting to that stage of how many more examples get the good result, and that keeps the confidence for the next project with similar builders.
- IN: What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance?**
- BI09: I mean the main thing is the complexity and the basic fundamental if you're relying on other people. It's very difficult, with engineering you can physically see something, with energy it's difficult to actually visualise what it's doing sometimes hoping just the right result comes out of the software. That would be the main problem.
- IN: What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision? (i.e.- structural changes to the system, changes to the roles and responsibilities of key players...etc) and how would you recommend that these be dealt with?**
- BI09: I think the main problem is the linkage with outside/above the building regulations items which planning require, BREEAM or whatever, which is a figure above the Part L. So the Part L is a basic level and then we come with all these other things and that's what makes the complexity, because you can go on site and as far as we're concerned for Part L, you're just dealing with Part L requirement. But the client and everyone else is going for a much higher standard than even you're asking. So it's the complexity of where the linkage is. If someone finds something much higher and you're caught in the middle of 'is the contractor pulling a fast one?' It's because you're asking for 100mm, but they require 300mm and the contractor turns around and says 'is 100mm ok?' and you say 'that meets building regs'.
- IN: How often do you think cyclic reviews of energy regulations should occur? (Expand to standstill period)**
- BI09: The problem is that people are still not aware of all the things and changes even now. The basis of the people out there who are sufficiently trained in dealing with what's there at the moment, to actually require

165 more, since it's being opened to other people, it's very difficult to impose things and then not even know things at a basic level. As I said we're dealing in the major projects, so generally it's the big companies and they're up to date.

**IN: So 4 years is enough as long as people know what they're doing?**

BI09: Yes, I think so.

170 **IN: And there's a standstill period when the regulations are published, do you think that's enough or do you think it should be extended?**

BI09: Sometimes, because people aren't aware they say 'oh, when's that coming in?' and it came in last year, so it's that information getting conveyed to people.

**IN: Should be extended to allow people to catch up?**

175 BI09: Not necessarily, it's just if they impose it, it's just the publicity of it then it suddenly seeps in.

**IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

BI09: As I said, it's the complexity, it's fundamentally the complexity of it really. It's just people on the ground, how they can actually have some input into it without it being just something abstract.

## B Interview 10 Transcript

**IN: Could you please give a brief description of the range of projects do you deal with?**

BI10: The projects I deal with range from small refurb, fit-outs that sort of thing all the way to multi-million redevelopments.

**IN: Are they usually non-domestic or domestic?**

5 BI10: They cross the whole range; domestic, commercial. The only thing we tend to not get in Westminster is industrial. We haven't got that much of a manufacturing base in Westminster.

**IN: On projects you have worked on, please describe the scope of your role and responsibilities.**

BI10: Well basically, obviously we're administering the building regulations as such. Effectively, it means we get involved with developers, architects, builders that sort of thing, hopefully at an early stage of negotiations.  
10 At that point obviously, we can give guidance as to what we're looking for on the submissions they make, not only on Part L but on all other aspects of it as well, because we're looking for compliance for the whole of the building regs, not just Part L.

**IN: What changes were made within your organisation to accommodate the introduction of Part L2A amendments in 2006? (increase in workload, costs...etc)**

15 BI10: I wouldn't have said that we made specific changes for L2 other than things like training, trying to keep staff abreast of what's actually happening to L2. So I don't think we made specific changes for L2 within our organisation as such other than- as I say- training, trying to get expertise within the specific fields in L2.

**IN: So you didn't notice an increase in workload or anything of that sort?**

BI10: In Westminster we don't normally notice an increase in workload. In the minute-it tended to be constant,  
20 obviously now there's a bit of downturn. But I wouldn't have said that there was an increase or decrease specifically related to L2.

**IN: Did you receive any training with regard to the new technical requirements of the Part L2A amendments? Please describe (method, duration, effectiveness...etc).**

BI10: It depended on seminars, that sort of thing, obviously reports coming in for other various organisations  
25 whether they're trade-like CIBSE, which are the engineers, that sort of thing- even the RICS, that sort of thing. But they were all putting on things like seminars, courses this sort of thing to obviously get people ready for L2-the whole Part L really- before it came out.

**IN: So it was from external sources?**

BI10: Yes, and internal, because obviously we can't send the whole department way on a course for a day or  
30 two. It's more of a question of right, you pick a percentage of staff and then get those staff to disseminate internally.

**IN: What is your degree of knowledge of the specific procedures and the tools used to demonstrate Part L2A compliance?**

BI10: Basically obviously it's all in Part L, how you comply with it. It does give you a range of options and it  
35 depends which way the developer wants to go.

**IN: So you're familiar with the national calculation methodology and the tools?**

BI10: There's more than one method in there of actually meeting the criteria and there's even methods for- I won't say getting out of the criteria- but for not quite bending the rules, but you don't have to comply with them if you fall within certain criteria as well.

40 **IN: From a regulatory sense, how effective is the NCM as a methodology for demonstrating compliance?**

BI10: Again, it's one method of demonstrating compliance. That's saying if you can do it by alternative methods, then you're quite free to do so.

**IN: So do you think it's effective?**

BI10: It is effective, but as I say, it's not the only way of doing it.

45 **IN: And how effective do you think the use of simulation tools is for calculating energy compliance?**

BI10: Simulation is quite effective, because obviously we get quite a lot of computer animated diagrams and what have you to show how things are actually going to work. And it's a way of doing it without building and going and testing it. It's quite useful.

**IN: At which stage of the design process does your involvement usually begin?**

50 BI10: Well being in sort of special projects, we tend to be involved at an early stage. Whether it's a redevelopment, whether it's an old building, whether it's minor alterations to buildings as such, we tend to be involved at an early stage and we can mention Part L. We obviously tend to look at things like structure and fire and Part M first- but we are also pulling in Part L, because we're finding that it can have a significant effect if you have to change it later.

55 **IN: So with regard to the RIBA stages, which stage would that be?**

BI10: Well, it depends on the development and to some extent in Westminster it depends on who the developer is and they know us. Some will come and see us even before they've made a submission, even to planning, just to talk about the proposal. So it can be that early on. Other who, shall I say are not familiar with us, will probably wait to sort of Stage C,D. Some have even left it till Stage E which they then find is getting a little bit late, especially when you go changing things.

**IN: Do you think involvement as early on as possible is effective in ensuring Part L2A compliance?**

BI10: Yes.

**IN: Please describe the impact of your involvement on the development of projects.**

BI10: Yes basically at that stage it's guidance to see how we review certain things – I'm trying to think in Part L terms if there's anything we'd look at-

**IN: Would you recommend any measures they take, things they do?**

BI10: Again it depends on what they're doing. I've got one at the moment whereby things like external cladding, there are seven different types of cladding on the building depending on the elevation and what it's actually doing and also that has a bearing on the insulation factors, not to mention solar gains, this sort of thing, which then again has a bearing on Part L. So it's a question of what they actually want to do in relation to what they really need to do in relation to for Part L.

**IN: Who is your usual point of contact on projects? (architect, contractor, client....etc)**

BI10: Obviously working on things like special projects, they tend to be expensive, so we tend to get involved with the developer and the architect at the early stage. (These) are the initial contacts, then we tend to get involved with the architect and the specialist consultants.

**IN: Do you view this to be the ideal person to interface with?**

BI10: We tend to prefer to deal with the expert in their field. Obviously, there's no point in me talking to the architect about finite details in Part L, if they've got a consultant on board who deals specifically with Part L. So we tend to prefer to deal with the expert in the field. Similarly, we wouldn't really talk to the architect about detailed structural matters, we'd talk to the structural engineer. It's the same thing.

**IN: Are they the person responsible for the Part L2A compliance simulation/calculation work?**

BI10: It's normally the architect, because it's part and parcel of the brief.

**IN: Would they do the calculations themselves?**

BI10: No, they would normally put it out to a consultant, but it would come in as a package from the architect and the architect would normally say 'this is going over my head just a little bit, can you deal with the consultant direct?' Can an architect be an expert in every matter to do with building regs? So you'd bring in specialists from their fields and it would be silly for us to talk through third-parties especially if it's only you're tending to change things drastically, you then need to involve the architect as in 'this doesn't work, you need to do something different'.

**IN: Which calculation tools/ methods are most frequently used to carry out this work?**

BI10: It tends to be wide a varied basically, it doesn't seem to be settled to one or two formats particularly at the moment, its coming in all different types.

**IN: Can you remember any of the names?**

BI10: Not specifically, unfortunately we can't read them on our computer systems. We occasionally have to go back and say 'can you change it and submit it in a different format?' That's mainly because of our system rather than anything laid outside.

**IN: With regard to Part L2A compliance, what kind of information do you require to be submitted? (e.g. modelling assumptions, HVAC systems..etc.)**

BI10: We do ask for more details, basically, rather than just the basic calculations.

**IN: Can you give an example of what you might ask them to submit?**

BI10: Rather than just calculations, how they've arrived at it, why they're using a particular type of system. A few years ago we had this problem about water cooling towers. That's a question of the systems they're using and why they're using that particular system to achieve a particular result.

**IN: So detailed assumptions that they've made and why?**

BI10: Obviously we'll start off with the basic 'this is what you need to comply with' and then it's a question of the details of how you've complied with it, why have you gone with that route rather than something else.

**IN: Do you require that they submitting the Part L2A work be certified under either of the accreditation schemes?**

BI10: It's not really part of our brief to do that. Obviously the architect is responsible and takes on the brief. It tends to part of their brief to make sure obviously who they are using are suitably qualified.

**IN: But you wouldn't check, you'd take the architect's word for it?**

BI10: We will tend to, yes.

**IN: Are there instances where you might accept Part L2A compliance demonstration via methods other than the NCM/simulation route? E.g. for overheating some people do hand calculations**

115 BI10: Yes, but if you're doing hand calculations, you're basing it on some formula we've already looked at. As long as they're tried and tested formulas, that sort of thing, there's no problem. The building regulations aren't that prescriptive and say you have to use this method. There's always something that says as long as you demonstrate by alternative methods that you are achieving the functions of the building regs, we look at it.

**IN: What measures do you take to ensure the validity of Part L2A compliance calculation/simulation results?**

120 BI10: Yes, that's why we have our own engineers. We have mechanical and ventilation engineers and structural engineers.

**IN: So the engineers specialised in that field will check the relevant sections?**

BI10: Yes.

125 **IN: In your opinion, how does energy efficiency compliance compare in terms of priority against more traditional health and safety aspects of the regulations?**

BI10: It's not obviously as important as life safety. But obviously it's getting to be more and more important.

**IN: So it's become more important in the past few years?**

130 BI10: Yes. I mean the original Part L was a minor part that people didn't think too much about. Now it can play quite a major part in the design. It has major implications for designs.

**IN: So in terms of ranked priorities, it would be?**

135 BI10: Life safety is obviously the prime concern, obviously things like structural safety comes within that as well. Then you're onto the other aspects what can you principle of the thing. Part M is still important, even though it's not life safety, its use of the building for occupants. This is where Part L is coming in on par with Part M. It's quite important yes, it can have major implications on design.

**IN: What is your assessment of the techniques adopted by building control to track Part L2A compliance over the course of a project and how significant is this in ensuring compliance?**

BI10: The same as we track other parts of the building regs. We need details of to make sure it complies.

**IN: So you think that plays a significant role in ensuring compliance?**

140 BI10: As I say, yes. We checking Part A, Part B, Part M, Part L tend to be the four main ones we look at. Part E is coming in as well, I'm trying to think, there's no point in mentioning Part H which is drainage and stuff. It's important in its own right, don't get me wrong on that, we'll still check that. But obviously we do track all parts of the building regs. If we've asked for it in the approval, then we'll track it.

**IN: So would that include things like on-site visits?**

145 BI10: It's on-site visits, it's recording data, it's recording information that's come in, details that we get in to make sure that they comply, that sort of thing. And it all goes on our records.

**IN: What are the main issues, if any, do you most frequently encounter with regard to Part L2A compliance?**

150 BI10: With the larger jobs, obviously Part L compliance is normally part and parcel of the consultant's job, that sort of thing and it's more of a question of checking what they're actually doing. With the smaller-I was going to say one-man bands- we're talking about a small change, say someone wants to put an extra storey on their house and because that tends to be done on a bit of a budget, this is where you tend to run into problems. Check Part L at the layman. Even if it's an office building and you want to extend it one storey, it's new build. Check Part L, it's someone who thinks they can do it. This is where the problems tend to occur, they don't

155 really know what they're getting into.

**IN: And what kind of problems would you face then?**

160 BI10: The problem you tend to face then is that they think that they can just stick a bit of mineral wool in the loft, insulation, that sort of thing. Or they put up a solar panel on the roof and they think they've done it. And it's not quite true and to take them through it and show them exactly what they need to do it's a bit time consuming and you're never really sure they've fully understood what you're talking about.

**IN: But with larger developments they tend to know what is going on?**

BI10: With special projects you tend to talk about multi-million and yes you employ a consultant and if you're employing a consultant, they normally get it right.

165 **IN: What are the key areas that should be prioritised with regard to the upcoming Part L 2010 revision? (i.e.- structural changes to the system, changes to the roles and responsibilities of key players...etc) and how would you recommend that these be dealt with?**

BI10: I think as I understand it, they're meant to simplifying it to make it easier to understand, which is



something we've been voicing since it first came out, and I think we're not the only ones.

**IN: So you think the current methodology might be a little too complex?**

170 BI10: Unless you are in the consultant field purely as an expert dealing with it, yes it does tend to be. Rather involved, rather complex. So simplifying it especially for the smaller projects should make it work a lot better.

**IN: So you're suggesting that they pass something a lot more simpler for the smaller projects?**

175 BI10: Well, if you've tried working through Part L, then you'll know what I mean. It seems to be a long winded process and what are you achieving at the end? From our point of view you're just checking data, that sort of thing, and does it really achieve it at the end? Then it goes and gets built, who actually goes and tests it after its in use? From our point of view we approve something, it's built, that's fine, we sign it off. Who would actually go and test it to make sure that it's actually working the way it should be. There doesn't seem to be the follow-up.

**IN: How often do you think cyclic reviews of energy regulations should occur?**

180 BI10: Probably the 4 -5 years yes, because you need to obviously catch up all the time.

**IN: And do you think a 6 month lead in period is enough?**

185 BI10: It depends on the changes they're making, basically. If they're minor changes that can easily be absorbed then 6 months is not a problem. But if all of a sudden you're upping the insulation values, there's a lot of different manufacturers who've got to do a lot of testing to see if their products actually meet it. And if they don't, how do they actually adapt them to make them meet that? It depends on the changes they're making, for sum 6 months is probably not long enough, others it's probably ok. It just depends on the changes.

**IN: So you think they should extend that?**

BI10: It would probably be better if they could. But not change the review period. Every 4-5 years you should be looking at it again.

190 **IN: In summary, how would you assess the overall procedure and how do you see it being improved?**

BI10: I think I've already said that. For smaller projects, obviously the simplification of the procedure will help.

**IN: And for the larger projects?**

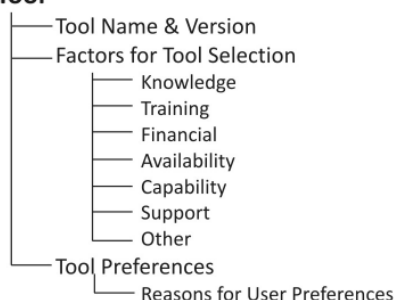
BI10: For the larger projects, because it tends to be done by someone who's specialising in it, it's not normally a problem.

195 **IN: And on the legislative side?**

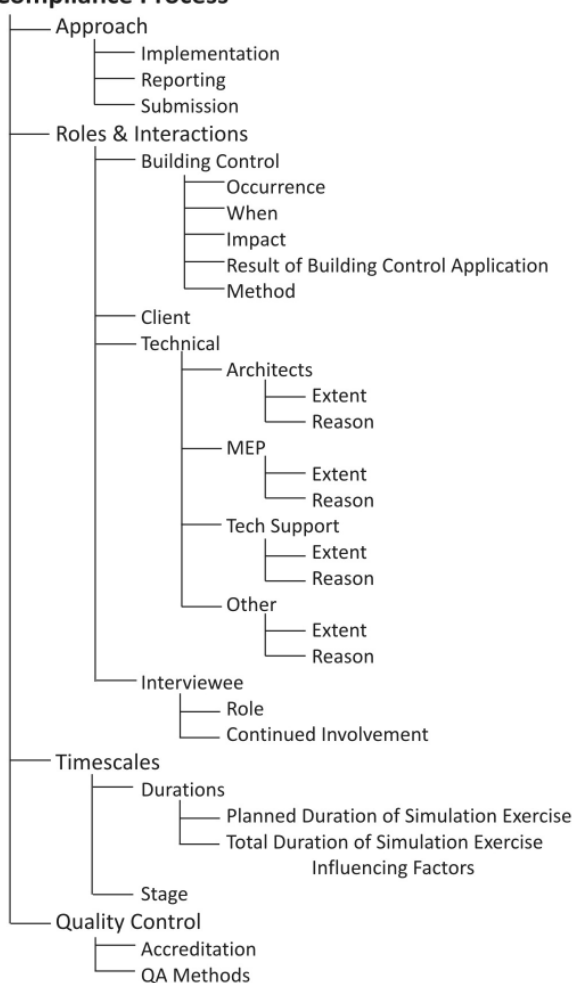
200 BI10: It wasn't specifically for Part L, initially it was one of our sort of problems mainly because again, the lead in wasn't really long enough. All of a sudden, here it's changed. I think it's more difficult with things like consultation and letting us know what's actually going to happen. It takes long enough for parliament to get through a change of legislation, that sort of thing, with the building regulations you don't need to do that, (he) only has to push it through. But obviously industry has to know about it and we need to know which way their thinking is going. On other aspects, for example things like ventilation shafts, Part B and things like fire fighting tool, staircases, that sort of thing, they've been changing every 6 months, every year, so how on earth do you put that into legislation, I have no idea. It keeps changing. Part L doesn't seem to be doing that at the moment, it's more like a slow progression, which seems to be a lot better in that respect. We can't but wait and  
205 see what they're going to do.

## Appendix E: Interview Themes and Sub-Themes

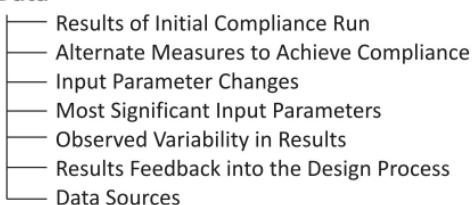
### A-Tool



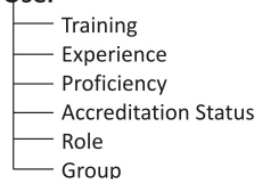
### B-Compliance Process



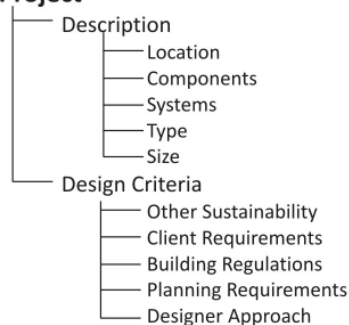
### C-Data



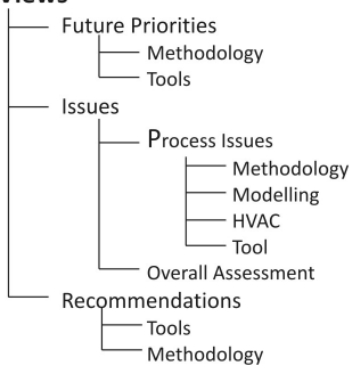
### D-User



### E-Project



### F-Views



## Appendix F: Key Interview Information

### 1-Interview Data Analysis Tables

Table A-F.1: Interview project information

Interview	Project Type	Location	Systems description	Renewables	Sustainability Targets
I01	School	Coventry	Mechanical ventilation	None	Part L2A
I02	Retail	Reading	Heated and cooled system with VAV systems, bookstore heaters & fan coils. Energy efficient lighting	Wind turbines, CHP (Tri-generation option)	Part L2A+10% CO <sub>2</sub> reduction from CHP+ renewables planning requirement
I03	Office	Hertfordshire	Mechanical ventilation, AHU fed with refrigerant water heat pumps. Energy efficient lighting/ daylighting control system n/a	PV, GSHP, solar thermal/air source hot water Unspecified renewables	Part L2A+BREEAM Excellent rating Part L2A +10% CO <sub>2</sub> reduction from renewables+ renewables planning requirement
I04	Office/ Hotel	London			
I05	College	London	Natural ventilation with stack effect, through an atrium to other areas which utilising mixing systems	Unspecified renewables	Part L2A+20% further improvement on Part L2A planning requirement
I06	School	Yorkshire	Natural ventilation. Gas site fired boilers for heating.	Unspecified renewables	Part L2A+ BREEAM target
I07	Retail	London	Site-wide centralised heat, power and chilled water distribution. AC with fan coils/chilled beams & large scale ventilation systems.	CHP or Tri-generation	Part L2A+ 10% further improvement + 20% Tri-gen improvement planning requirement
I08	School	Reading	Mechanical ventilation with heat recovery. Underfloor heating, heating and cooling coils.	GSHP	Part L2A
I09	Residential	Grimsby	Main heating system via heat pump & biomass boiler	Solar thermal hot water + Bio mass boiler	Part L2A+50% renewable/low carbon energy source
I10	School	Barking	Gas boilers and chilled beams for cooling.	GSHP	Part L2A
I11	School	Essex	AC with local mechanical ventilation for individual areas. Centralised heating system/boiler radiator heating underfloor heating. Mixed fluorescent /tungsten lighting.	n/a	Part L2A
I12	Sports Centre	East England	Complex HVAC systems including AC/mechanical ventilation/VAV	n/a	Part L2A
I13	School	Milton Keynes	n/a	n/a	Part L2A+25% energy reduction on standard practice and a 10% renewable requirement
I14	Office	London	Water-cooled chiller with efficient boilers	CHP+ fuel cell installation	Part L2A+ 20% CO <sub>2</sub> reduction GLA requirement from renewable
I15	Multiuse (Electrical hub building/ Office)	Yorkshire	Natural ventilation & heating	n/a	Part L2A+ green design features

Table A-F.2: Stakeholder dynamics: Functions and impacts

Stakeholder	Main Function	Impact
<b>Architect/Designer</b>	Building design: generally not involved with Part L2A calculations (BI01, BI02) and/or not familiar with procedures (BI01). Performed two functions integral to the process; provision of information required for the compliance process (design drawings & material U-values).	The degree of knowledge with regard to building regulations had in general decreased over the years due to the increased complexity of regulations (BI06). Scope and actual degree of involvement will vary according to project stage and size. In general, the principal & most productive point of contact point with BCBs (BI01, BI02, BI04, BI05, BI06, BI10). Extended Involvement resulted in a more active role in an integrated design process & the development of an informed sustainable design program (I04, I03).
<b>Building Services</b>	Implementation of principal functions associated with Part L2A calculations (e.g. I01, I02, BI02, BI03, BI05, BI07, BI08, BI09, BI10). Often managed and appointed by the architect.	Direct engagement facilitates information exchange and design discussions, aiding in making required iterations. Preferred point of contact for this specific area since they were considered to be one of the key people with the required technical knowledge to address queries (BI07).
<b>Energy Consultants</b>	General sustainability consultation & implementation of principal functions associated with Part L2A calculations (e.g. I01, I02, BI02, BI03, BI05, BI07, BI08, BI09, BI10). Often managed and appointed by the architect.	Direct engagement facilitates information exchange & design discussions, aiding in making required iterations (BI07).
<b>Technical Support</b>	Assistance with modelling, feedback about assumptions & most importantly, addressing software bugs. Involvement increased with project size and complexity.	Availability of capable technical support was an integral factor in tool selection. Also served for training purposes (I01).
<b>The Client</b>	The extent & form of involvement has evolved in recent years to role of principal contact (BI03, BI08, BI10), influencing aspects such as the early appointment of BCBs (BI07). It has therefore become integral that clients are therefore kept well informed (BI08).	Enhanced sustainability agenda was often client-driven (I15, I03) in an aim to tackle sustainability issues, improve the energy performance & consequently increase the value of their portfolio.

Table A-F.3: Participant role categories

Role	Format, Scope and Function
<b>Implementation of calculation</b>	<ul style="list-style-type: none"> <li>In singular or group capacity (specialist/internal sustainability group-I01) or as appointed consultants alongside the services group to the client (I05) or contractor (I13). Control of the calculations is often centralised but with information gathered from different parties.</li> <li>Junior members of staff given the responsibility for tasks such as data preparation and input (I03).</li> <li>On most occasions contact is lost with the project after calculation submission (I15)</li> </ul>
<b>Supervisory &amp;/or quality control</b>	<ul style="list-style-type: none"> <li>Participants did not undertake the calculation work, but were directly responsible for overseeing it in a QA capacity.</li> <li>Often supervisory roles were implemented in a colleague training system (I06), maintaining ultimate responsibility with more experienced staff members (I03).</li> </ul>
<b>Design responsibilities</b>	<ul style="list-style-type: none"> <li>When the implementer of the calculation is part of the services group who are responsible for designing the HVAC systems (I14) or within the same company as those who do the MEP and architectural design (I15).</li> </ul>
<b>Client/contractor/ designer arrangement Inspection</b>	<ul style="list-style-type: none"> <li>In addition to carrying out the calculation, the participant's role and involvement was maximised (I03, I12).</li> <li>Continued role, encompassing responsibility of associated inspection tasks following the calculation such as follow-up site visits to ensure that specified equipment was installed (I02).</li> </ul>

Table A-F.4: Information sources

Information	Source(s)
<b>Architectural Drawings</b>	Architect
<b>HVAC Systems Design Specifications</b>	MEP Designers /Engineers/Specialised Contractor
<b>Envelope Design/Facade Specifications</b>	Architect
<b>Construction Material U-values</b>	Architect
<b>Lighting Design &amp; Specifications</b>	MEP Designers /Engineers

Table A-F.5: Factors affecting tool selection

Factor	Impact
<b>Availability</b>	<ul style="list-style-type: none"> <li>Several participants reported a particular tool was used due to its availability in the company or organisation (I02, I06, I07, I08, I10, I11, I13).</li> </ul>
<b>Capability</b>	<ul style="list-style-type: none"> <li>DSMs were popularised due to the fact that SBEM was limited in its capabilities beyond Part L (I01, I02, I06, I08) &amp; they could be used in design support as well as in regulatory compliance calculation and demonstration (I04), especially for complex buildings where more advanced simulation would be required. (I14 and I13).</li> </ul>
<b>Financial factors</b>	<ul style="list-style-type: none"> <li>Often significant when the frequency of doing Part L2 calculations did not justify investing in high cost software, consequently leading to the use of the free tool.</li> </ul>
<b>Knowledge of tool and training</b>	<ul style="list-style-type: none"> <li>Since the concept involved in the application of the NCM process is a novel one, the availability of adequate training to enable users to adequately apply it (I15), knowledge of the tool (e.g. I04, I13) was a significant factor.</li> <li>Some companies invested in tools that had a pre-trained user base (e.g. university based training that took place using a particular tool-I13).</li> </ul>
<b>Availability of technical support</b>	<ul style="list-style-type: none"> <li>The provision of adequate technical support to answer user queries &amp; address issues in the application of the methodology (I01).</li> </ul>
<b>Other factors</b>	<ul style="list-style-type: none"> <li>Includes perceived user friendliness of the interface (I09) &amp; the undertaking of additional certification requirements such as EPCs.</li> </ul>

Table A-F.6: Building Control Bodies: format, scope and functions

Role	Format, Scope and Functions
<b>Local Authority Building Control (LABC)</b>	<ul style="list-style-type: none"> <li>Includes some guidance but more significantly involves ensuring enforcement at submission stage (BI08, BI09, BI10).</li> <li>Involves tasks such as vetting applications &amp; receiving and checking SBEM documentation, checking plans &amp; the accreditation of individuals &amp; may extend to on-site inspections (BI01, BI08, BI09, BI10).</li> </ul>
<b>Approved Inspectors (AI)</b>	<ul style="list-style-type: none"> <li>Either appointed to the design team or directly to the client to oversee the overall building regulation compliance (BI07).</li> <li>Their function moves away from compliance checking to compliance auditing during the design process &amp; inspection during construction. (BI02).</li> <li>Within the specialised context of Part L2A compliance, the range of tasks is in general more extensive, advising on methods of compliance &amp; trying to assist the project team in achieving cost certainty &amp; risk reduction (BI03, BI06).</li> <li>Involvement extends beyond submissions under building regulations to include any associated legislation, such as British standards &amp; CIBSE Guides (BI04).</li> </ul>
<b>Planning*</b>	<ul style="list-style-type: none"> <li>In addition to Part L compliance, the planning department in local authorities often gets involved to ensure that the planning requirements that they set out are met as well as (BI01).</li> <li>This involvement can potentially lead to confusion due to factors such as inconsistent application of the guidance across authority boundaries &amp; within authorities themselves (e.g. the case of the GLA) &amp; the definition of targets (e.g. 10% low &amp; zero carbon (BI05).</li> </ul>

\*Although planning is not traditionally regarded as building control, their roles often overlap in areas such as the enforcement of sustainability targets

Table A-F.7: Impact of input parameters on results

Parameter	Reported Impact
<b>Re-assignment of systems</b>	20% reduction in CO <sub>2</sub>
<b>Lighting, system efficiencies &amp; specific fan power.</b>	10-15% reduction in CO <sub>2</sub>
<b>Lighting, air leakage &amp; building services</b>	`significant`
<b>Lighting</b>	10% reduction in CO <sub>2</sub>
<b>Lighting &amp; systems</b>	25% reduction in CO <sub>2</sub>
<b>Lighting &amp; lighting control</b>	10%
<b>Cooling &amp; lighting</b>	5-10% reduction in CO <sub>2</sub>
<b>Building envelope U-Values and efficient heat pumps.</b>	30% reduction in CO <sub>2</sub>
<b>Lighting &amp; boiler efficiencies.</b>	Can't remember
<b>Profiles</b>	Difference between Pass and Fail
<b>Profiles</b>	25% reduction in CO <sub>2</sub>
<b>Heating load, HVAC systems &amp; lighting</b>	20-50% reduction in CO <sub>2</sub>
<b>Boiler efficiencies, domestic services, heating efficiencies &amp; lighting controls</b>	5-7% reduction in CO <sub>2</sub>
<b>Lighting</b>	`significant`
<b>G-values &amp; facade design.</b>	5% reduction in CO <sub>2</sub>

Table A-F.8: Quality assurance procedures

Method	Description
<b>Prior to Submission</b>	
<b>Limited or no QA procedures</b>	No formal assessment system exists (I01).
<b>Self Checking</b>	Participant rechecks the work, mainly relies on personal experience (I03,I10).
<b>Simple checking by a peer/supervisor</b>	A supervisor or peer (often accredited-I01) sometimes with the aid of checklist will quickly go over the model or the report before it is issued/submitted.
<b>At Submission and Enforcement</b>	
<b>Verification of Information</b>	Involves a minimal check to establish if the calculation has been carried out by an accredited/competent individual, check the validity of material U-Value assumptions (BI04, BI05,BI07,BI08, BI09,BI10), followed by on-site inspections to check that design measures have been carried on to the actual building (BI0).
<b>Calculation Audits</b>	Involves running calculations past an appointed services consultant to check validity (BI02).Adopted when the individual was not accredited.
<b>Site Inspections</b>	Involves on-site visits, recording data & information & verifying that constructions complied (BI10).Since there was no statutory requirement for inspections (BI01) & no mandatory standard procedure. These vary greatly & are subject to and dependant on the quality of available site supervision (BI09).

## 2-Detailed Discussion of Issues

### Issues with the methodology

<b>a. Methodology</b>  <b>Complexity</b>	<p>The increased complexity &amp; specialisation was the main issue affecting the implementation of the methodology (I04, BI09). While it had previously been a fairly straightforward process to achieving compliance, the introduction of the NCM methodology required that the design team carry out a lot more work to show compliance for the buildings (BI06), &amp; with regard to BCBs consequently required the assistance of specialists &amp; experts to support the understanding &amp; enforcement of procedures (BI06, BI08, BI09, BI10).</p>
<b>b. Methodology</b>  <b>Flexibility&amp;</b>  <b>Transparency</b>	<p>Although parts of the calculation methodology had been published at that point, the full methodology remained unavailable (I06). This was one of the issues that impacted the perceived transparency of the methodology, which was described as a 'black box' (I11), 'convoluted' (I09-Line 247) 'overly complicated' &amp; lacking in transparency (I10-Line 161). The perceived lack in transparency in procedures impacted on the ability of users to understand how it operated &amp; to trace sources of error in unexpected results (I06, I11).</p>
<b>c. Realism</b>	<p>The current methodology was perceived to give less realistic &amp; reasonable results than those produced by the similar carbon emissions calculation methodology from the Part L 2002 version of the regulations which allowed the user to choose the occupancy, equipment &amp; lighting profiles to suit the actual building (I05).</p> <p>The method was considered to be largely ineffective in interpreting the real design in model form with the software (I01, BI09), modelling novel designs &amp; complex systems configurations (I01) &amp; representing the interaction between building systems. This manifested in there being a compliance bias in favour of air-conditioned heated &amp; cooled buildings with difficulties encountered in passing naturally ventilated buildings (BI07) which in reality were more likely to consume less energy (I02). Furthermore, although compliance should be demonstrated at two stages (as-designed &amp; as-built), in many cases the as-built calculation would be overlooked &amp; only the EPC certificate would be required, further disassociating the compliance calculation from the actual building (I04).</p>
<b>d. Occupancy</b>  <b>&amp; Activity</b>  <b>Profiles</b>	<p>The NCM profiles that were used by all tools to generate the occupancy data &amp; the usage data for the Part L2A calculations were considered unrealistic, overestimating aspects such as lighting, small power load &amp; hot water consumption in particular building types (I04, I05) creating loopholes that could be taken advantage of in the model to achieve compliance. Other issues include building types which don't have the right room activities assigned to them, the lack of provisions for modelling residential buildings (over 450m<sup>2</sup>) &amp; the unavailability of profiles for features such as night-purge. Since no guidance was given, participants wrote &amp; assigned them based on their own experience (I15).</p>



<b>Issues with software</b>	
<b>a. Software modelling capabilities</b>	<p>The major problems associated with compliance software were tool complexity &amp; various technical limitations (I06). The latter issue, especially evident in the default iSBEM tool (I01,I02,I06), was of a major concern since available tools were reported to be lacking in the flexibility required to suit all circumstances &amp; reflect how buildings were actually constructed (BI02), which consequently viewed to disassociate the compliance calculation from the actual building. These shortcomings were especially evident in areas such as the lack of representativeness in modelling the HVAC systems used in the actual design (I01, I05, I05, I07, I13, I14,BI09) &amp; the incorporation of the effect of renewable technologies, despite the regulations &amp; planning requirements put in place by the government to promote their use (I03, I04).</p> <p>In these cases, participants were likely to resort to making judgements &amp; on what best reflected reality (I07,I08), create work-around compromises to represent the system (I05) &amp; when there was no way of effectively incorporating renewables into the model, they were added on as a post-processing exercise (I05).</p>
<b>b. Software suitability &amp; complexity</b>	<p>Participants stated that software tools were 'more complicated than need to be' (I09) &amp; 'clunky &amp; difficult to use' (I08) &amp; felt that it would take quite a considerable amount of time to 'learn the nuances &amp; the problems with the software &amp; how to get round them' (I04). The default calculation tool iSBEM was reported to be complicated, not user friendly &amp; incredibly difficult to use (BI07, BI02). The tool was reported to be un-intuitive &amp; did not follow any logical pattern &amp; was inflexible in terms of making alterations to the model (BI01).</p> <p>While the accreditation process had been introduced to ensure that the available commercial tools were adequate for the purposes of Part L2A compliance demonstration, some of the most popular commercial tools were perceived to be less suited to implementing compliance checking (I12).</p> <p>A preference for tools that had been developed with Part L2A in mind over ones that had been modified to accommodate Part L2A calculations was stated since the latter often had a less user friendly interface &amp; required multiple data in different modules to enable the creation of a Part L2A model (I07) resulting in a long winded compliance checking process (I12).</p>
<b>c. Programming errors &amp; software bugs</b>	<p>Software, especially early on in the implementation of the new regulations, was described as being 'filled with lots of bugs' (I02, I09) which often caused the program to crash when running simulations &amp; were thought to be responsible for the discrepancies that were found between the data that was input &amp; what was contained in the BRUKL output document.</p>
<b>d. Lack of technical support</b>	<p>As previously mentioned, the existence of adequate technical support was an integral factor in tool selection to the extent that the choice was made to</p>

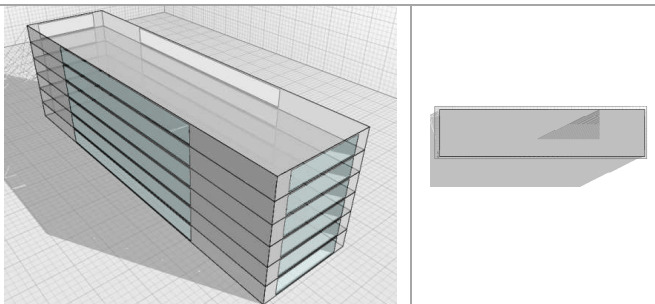
	<p>switch from one commercial DSM tool to the other, because the latter's technical support unit were unwilling to deal with issues reported by the participant (I01). Despite SBEM being the default tool, technical support via the previously existing telephone helpline had been suspended 'The problem I have is that if you're so engrossed in a calculation &amp; are under pressure to create that calculation, you really need the answer (I03), therefore undermining the large user-base's ability to use it. It was reported that people were not able to use tools properly, which required BCBs involvement. This was especially true for smaller projects (BI05).</p>
<b>e. Results variability</b>	<p>User based factors were recognised as one of the potential causes of results variability (I05). However, differences in input, assumptions &amp; modelling methodology between tools also added up to significant variations in potential output for a project (I05, I06) which was very common between different software packages (I02). With regard to assumptions, participants identified several potential causes for the variation between SBEM &amp; commercial DSMs such as the methodology used for the estimation of lighting consumption (I05). Participants also reported that differences existed between different versions of the same tool, with the earlier version passing the model &amp; the newer version failing it (I09). The importance of eliminating variability between different software tools (I06), standardising known variations in assumptions to find a way of ensuring results consistency (I02) was recognised.</p>
<b>f. Problems with the accreditation</b>	<p>Accreditation procedures (in particular the TM33 for DSMs) were frequently cited as a potential source of a number of the previously mentioned problems. Participants believed that the accreditation process was not stringent enough &amp; insufficiently rigorous to ensure tool suitability for the purposes of compliance demonstration (I01). In particular, while the TM33 procedure for DSMs validated software for routines for data input &amp; results production, it was felt that it didn't sufficiently address the calculation algorithms &amp; how the Part L2A results were produced (I06).</p>

<b>Issues with enforcement</b>	
<b>a. A lack of mandatory inspection procedures</b>	Since no specific procedures were mandated, inspection procedures varied greatly & were dependant on the quality of available site supervision to make certain that due diligence is carried out by the contractor on site (BI01, BI03, BI05), which most believed was detrimental to the enforcement of Part L2A.
<b>b. A lack of consistency in enforcing multiple energy targets</b>	In addition, one of the main problems that were highlighted was the lack of consistency & linkage with targets outside/above the building regulations items. This included the lack of integration & interpretation of multiple energy targets enforced by various parties such as building regulations energy compliance, planning renewables requirements & BREEAM sustainability targets (BI05, BI08, BI10).
<b>c. Continual amendments created confusion</b>	The change of the culture from the previous to the new Part L was fundamental in creating a lot of issues with architects an M&E engineers (BI07), & the use of transitional provisions caused significant confusion (BI01) which was compounded by an insufficient lead in period & inadequate provision of information outlining the changes beforehand (BI10).
<b>d. Compliance documents only provide a snapshot</b>	Since compliance documents only provided a `snapshot` of the building at a certain point that will only give an indication if compliance is achievable in the end product, but does not in any way guarantee it (BI03). A fundamental issue that is especially evident in smaller & medium sized architects & developers is that they produce the BRUKL document to show compliance & fail to go beyond that requirement (BI07).

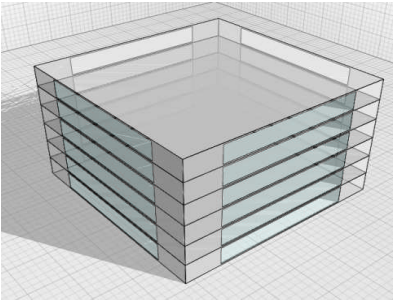
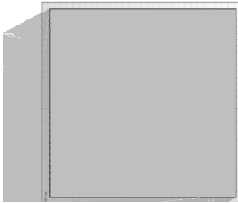
<b>Issues with Information</b>	
<b>a. Lack of procedural information</b>	Early on in during the first two years following the initial implementation of the Part L2A amendments, participants reported that there was a lack of information required to outline the procedural changes. Consequentially, this led to several parties being unaware of Part L2A & its requirements until these were outlined by building control (BI01).
<b>b. Lack of industry communication, education &amp; knowledge</b>	Due to the lack of communication & education (BI03), the main issues that affect the design stage are the lack of knowledge & understanding of the design team, who are sometimes unaware of need to carry out compliance demonstration or the associated detailed information that must be provided accordingly (BI06).
<b>c. Provision of supplementary information for the BRUKL document</b>	Issues with regard to difficulties in interpreting the information in the BRUKL document which refers to additional supplementary information were reported. This was thought to be a product of general lack of recognition of industry professional as to the importance of providing supplementary information, which people find difficult to provide (BI02).
<b>Issues with Personnel</b>	
<b>a. Architects lack sufficient knowledge</b>	Although architects were often cited as the primary point of contact on projects, with the exception of rare cases (BI05) they did not carry out the Part L2A calculations themselves (BI01, BI02) & were not familiar with the Part L2A calculations (BI01). Many architects, especially those involved in smaller projects, were more likely to rely on the local authorities or approved inspectors as consultants to educate them with regard to the requirements of the current standards (BI01, BI06). It was mentioned that the degree of knowledge that architects had with regard to building regulations had in general decreased over the years due to the increased complexity of regulations (BI07), the introduction of various sustainability codes, & the challenges of the increasing stringent planning requirements (BI06).
<b>b. Lack of knowledge of the design team</b>	Due to the lack of communication & education (BI03), the main issues that affect the design stage are the lack of knowledge & understanding of the design team, who were not aware of the major impact, especially financially, that Part L could potentially have on the project (BI03).
<b>c. Negative perceptions of Building Control</b>	One of the major issues is perhaps the perception of the building control practitioners involved, who are in some cases viewed as the 'building police' rather than part of a system that is design to assist in the design & construction process (BI05).
<b>d. Lack of adequate technical support</b>	The general issues encountered with technical support include their unwillingness to deal with particular cases (I01) or the tendency to give mathematical answers to engineering problems, since they were not specifically trained or well-versed that field (I14).

## Appendix G: Model Variant Input Information

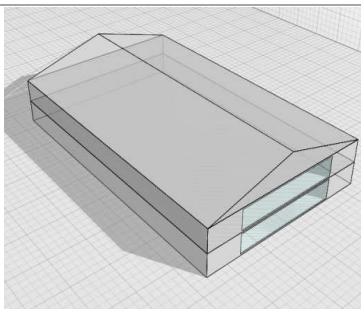

### 1-Variant 1

<b>Variant 1</b>					
<b>General Description</b>	Six Storey Shallow Plan Office				
<b>Building Type</b>	Office				
<b>Configuration</b>	Medium Rise-Shallow Plan				
<b>Location</b>	London				
<b>Coordinates</b>	51° 30' 28" N, 0° 7' 41" W Decimal 51.507778°, -0.128056°				
<b>Weather File</b>	London, UK				
<b>Geometry</b>					
Width	15m	Length	60m	Floor Height	3.7m
Number of Floors	6	Total Floor Area		5400m <sup>2</sup>	
<b>Opaque Materials</b>		<b>Type</b>	<b>U-Value Wm<sup>2</sup>/k</b>	<b>Km Value kj/m<sup>2</sup>k</b>	
<b>External Walls</b>		Cavity Wall E&W 2006 Full Fill	0.27	129	
<b>Ground Floor</b>		Solid Ground Floor E&W 2006	0.22	36	
<b>Floors</b>		Office-E&W 2006 Solid (inf procedures)	0.22	36	
<b>Roof</b>		Flat Roof-E&W 2006 Concrete Deck	0.16	225.7	
<b>Ceiling</b>		Office-E&W 2006 Solid (inf procedures)	0.22	36	
<b>Transparent Materials</b>		<b>Property</b>	<b>U-Value Wm<sup>2</sup>/k</b>	<b>T-Solar</b>	<b>L-Solar</b>
<b>Glazing Material</b>		4-12-4-12-4 Triple glazed argon filled-low-e	1.529	0.64	0.7
Glazing Area		60% of Total Wall Area			
Window Dimensions		Short= 3.33 m <sup>2</sup> , Long=133.2 m <sup>2</sup>			
Shading		On all External Glazing			
<b>Systems</b>					
<b>HVAC System Type</b>		Chilled Ceilings or Chilled Beams & Displacement Ventilation			
<b>Heating System</b>		LTHW Boiler			
Fuel Type		Natural Gas-Also uses CHP			
Effective Heat Generating Seasonal Eff.		Default Value (0.89)			
Generator Radiant Eff.		Default Value (0.4)			
Heating System Controls		Central Tome Control/Optimum start stop/weather comp			
<b>Cooling System</b>		Default Chiller			
Generator Type		Water Cooled Chiller			
Generator KW		Up to 100 kw (def)			
Fuel Type		Grid Supplied Electricity			
SEER		Calculated Value (3.78)			
Generator Nominal Eff.		Calculated Value (3.78)			
<b>Ventilation</b>		Heat Recovery-Plate Heat Exchanger (Recuperator) Eff= 0.65			
Specific Fan Power		2.5 (maximum allowable -non-domestic compliance guide)			
<b>DHW</b>					
Generator Type		Dedicated Hot Water Boiler			
Fuel Type		Natural Gas			
Seasonal Eff.		0.745 (calculated-min req + control credits)			
<b>Lighting</b>					
Type		T5 Fluorescent Lighting			
Occupancy Controls		AUTO-ON-OFF			
<b>Loads</b>					
Occupancy		1 person/14m <sup>2</sup> - at 130 watts= 9.4 w/m <sup>2</sup>			
Equipment		7.9 m <sup>2</sup>			
Lighting		9.4m <sup>2</sup>			
<b>Rates</b>					
Infiltration Rate		0.05 ach			
<b>Renewables</b>					
<b>PVs</b>					
Available roof space		900m <sup>2</sup>			
Suggested PV installation		450m <sup>2</sup> of PV on flat surface (inclination 0)			
Type		Uses 350 modules, c-Si-Monocrystalline			
<b>Suggested wind installation</b>		10 no. 1.5kW turbines (approx 3 m diameter from source info)			
<b>Suggested CHP installation</b>		Natural Gas, 0.47electrical efficiency, 0.8 heating efficiency			
<b>CHPQA</b>		150 (Minimum reqs)			
<b>Heating Supplied</b>		50%			
<b>Water supplied</b>		0%			

## 2-Variant 2

<b>General Description</b>	Six Storey Deep Plan Office	 			
<b>Building Type</b>	Office				
<b>Configuration</b>	Medium Rise-Deep Plan				
<b>Location</b>	London				
<b>Coordinates</b>	51° 30' 28" N, 0° 7' 41" W Decimal 51.507778°, - 0.128056°				
<b>Weather File</b>	London, UK				
<b>Geometry</b>					
Width	30m	Length	30m	Floor Height	3.7m
Number of Floors	6	Total Floor Area		5400m <sup>2</sup>	
<b>Opaque Materials</b>		<b>Type</b>	<b>U-Value Wm<sup>2</sup>/k</b>	<b>Km Value kj/m<sup>2</sup>k</b>	
External Walls		Cavity Wall E&W 2006 Full Fill	0.27	129	
Ground Floor		Solid Ground Floor E&W 2006	0.22	36	
Floors		Office-E&W 2006 Solid (inf procedures)	0.22	36	
Roof		Flat Roof-E&W 2006 Concrete Deck	0.16	225.7	
Ceiling		Office-E&W 2006 Solid (inf procedures)	0.22	36	
<b>Transparent Materials</b>		<b>Property</b>	<b>U-Value Wm<sup>2</sup>/k</b>	<b>T-Solar</b>	<b>L-Solar</b>
Glazing Material		4-12-4-12-4 Triple glazed argon filled-low-e	1.529	0.64	0.7
Glazing Area		60% of Total Wall Area			
Window Dimensions		Short= 3.33 m <sup>2</sup> , Long=133.2 m <sup>2</sup>			
Shading		On all External Glazing			
<b>Systems</b>					
<b>HVAC System Type</b>		Chilled Ceilings or Chilled Beams & Displacement Ventilation			
<b>Heating System</b>		LTHW Boiler			
Fuel Type		Natural Gas-Also uses CHP			
Effective Heat Generating Seasonal Eff.		Default Value (0.89)			
Generator Radiant Eff.		Default Value (0.4)			
Heating System Controls		Central Teme Control/Optimum start stop/weather comp			
<b>Cooling System</b>		Default Chiller			
Generator Type		Water Cooled Chiller			
Generator KW		Up to 100 kw (def)			
Fuel Type		Grid Supplied Electricity			
SEER		Calculated Value (3.78)			
Generator Nominal Eff.		Calculated Value (3.78)			
<b>Ventilation</b>		Heat Recovery-Plate Heat Exchanger (Recuperator) Eff= 0.65			
Specific Fan Power		2.5 (maximum allowable -non-domestic compliance guide)			
<b>DHW</b>					
Generator Type		Dedicated Hot Water Boiler			
Fuel Type		Natural Gas			
Seasonal Eff.		0.745 (calculated-min req + control credits)			
<b>Lighting</b>					
Type		LED Lighting			
Occupancy Controls		AUTO-ON-OFF			
<b>Loads</b>					
Occupancy		1 person/14m <sup>2</sup> - at 130 watts= 9.4 w/m <sup>2</sup>			
Equipment		4.4 m <sup>2</sup>			
Lighting		6.2m <sup>2</sup>			
<b>Rates</b>					
Infiltration Rate		0.05 ach			
<b>Renewables</b>					
<b>PVs</b>					
Available roof space		900m <sup>2</sup>			
Suggested PV installation		450m <sup>2</sup> of PV on flat surface (inclination 0)			
Type		Uses 350 modules, c-Si-Monocrystalline			
<b>Suggested wind installation</b>		10 no. 1.5kW turbines (approx 3 m diameter from source info)			
<b>Suggested CHP installation</b>		Natural Gas, 0.47electrical efficiency, 0.8 heating efficiency			
<b>CHPQA</b>		150 (Minimum reqs)			
<b>Heating Supplied</b>		50%			
<b>Water supplied</b>		0%			

## 3-Variant 3

General Description		Retail Shed											
Building Type		Retail											
Configuration		Low Rise-Pitched Roof											
Location		London											
Coordinates		51° 30' 28'' N, 0° 7' 41'' W Decimal 51.507778°, -0.128056°											
Weather File		London, UK											
Geometry													
Width		25m		Length		40m		Floor Height		4m			
Number of Floors		2 storeys x 4m (with pitched-roof space, height at apex of 3.5m)				Total Floor Area		2000m <sup>2</sup>					
Opaque Materials				Type				U-Value Wm <sup>2</sup> /k		Km Value kj/m <sup>2</sup> k			
External Walls				Light Steel Framing 75 mm polyurethane				0.27		11.7			
Ground Floor				Solid Ground Floor E&W 2006				0.22		36			
Floors				Retail-E&W 2006 Suspended (inf procedures)				0.22		22.5			
Roof				Retail-E&W 2006 Suspended (inf procedures)				0.22		22.5			
Ceiling				Pitched roof coated metal (inf procedures)				0.13		8.55			
Transparent Materials				Property				U-Value Wm <sup>2</sup> /k		T-Solar		L-Solar	
Glazing Material				4-12-4-12-4 Triple glazed argon filled-low-e				1.529		0.64		0.7	
Glazing Area				60% of <u>Front</u> Wall Area									
Window Dimensions				TBD									
Shading				None									
Systems													
HVAC System Type				Active Chilled Beams									
Heating System				LTHW Boiler									
Fuel Type				Natural Gas-Also uses CHP									
Effective Heat Generating Seasonal Eff.				Default Value (0.89)									
Generator Radiant Eff.				Default Value (0.4)									
Heating System Controls				Central Tome Control/Optimum start stop/weather comp									
Cooling System				Default Chiller									
Generator Type				Water Cooled Chiller									
Generator KW				Up to 100 kw (def)									
Fuel Type				Grid Supplied Electricity									
SEER				Default Value (2)									
Generator Nominal Eff.				Default Value (2.5)									
Ventilation				Heat Recovery-Plate Heat Exchanger (Recuperator) Eff= 0.65									
Specific Fan Power				2.5 (maximum allowable -non-domestic compliance guide)									
DHW													
Generator Type				Same as HVAC(WC)									
Fuel Type				N/A									
Seasonal Eff.				N/A									
Lighting													
Type				Combination of fluorescent & halogen lighting									
Occupancy Controls				None									
Loads													
Occupancy				17.5 W/ m <sup>2</sup>									
Equipment				2.2W/ m <sup>2</sup>									
Lighting				20 W/m <sup>2</sup>									
Rates													
Infiltration Rate				0.05 ach									
Renewables													
PVs													
Available roof space				approx 1000m <sup>2</sup>									
Suggested PV installation				400m <sup>2</sup> of PV on south-facing pitched surface									
Type				Uses 310 modules at 30deg-Monocrystalline									
Suggested wind installation				12 no. 1.5kW turbines (approx 3m diameter from source info)									
Suggested CHP installation				Fuel-cell, 0.47 electrical efficiency, 0.5 heat efficiency									
CHPQA				150 (Minimum reqs)									
Heating Supplied				50%									
Water supplied				0%									